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Soil, Earth and People - Our Care and Responsibility

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Abstract

The article discusses the relationship between soils, land modern man and his concern and responsibility for sustainable land management. The main problems, which limit the rational use and protection of land are analyzed and also on the first place among them the improper and unfair distribution of fertile soils and lands, and the resulting problems on a different nature – geographic, demographic, ecological, food consumption and social onece. The significance of the triadic paradigms "soil-land-people", "capital-labor-science" and "wisdom-harmony-prosperity" is noted as well as the maxims that oblige us to work on them. It is also emphasized that soils in Bulgaria are subject to natural, anthropogenic and technogenic pressures. Problems are outlined which are related to arable land, recommendations, guidelines and critical assessments of the soil scientists and the European institutions (European Parliament and European Commission on Agriculture and Development of Rural Areas) concerning the organization and management of soil and land resources.

Key words: sustainable land management, soil, land, people, problems, overconcentration of land and finances, recommendations, guidelines, land use, conservation

Sustainable Land and Human Resource Management - Cardinal and Global Problem.

Sustainable management of soil, land and human resources is a cardinal and global problem for harmonizing the attitude of our society, people and nature. On the first place it is the issue of the unequal and unfair distribution of soils and lands since their origin and the planet formation as well as the last 150 years of intensive use of earth resources (Teoharov, 2006). This problem also raises the following issues - physiographic, demographic, food and environmental ones

Why Physical, Geographic and Demographic Problem?

1. It is a well-known fact that of the total land area of the planet, which is 30%, only 10-11% is arable land and soil. The other part are deserts, rocks, swamps, tundra, waterways, coastal streams, ravines, gullies, quarries, ballasts, disturbed and polluted territories, deserted and abandoned lands.

2. Every person living on the planet now has about 0.27 ha of land, while it is necessary to have 0.6 to 0.8 ha. For comparison, every Bulgarian citizen owns about 0.5 ha of land, significantly less than the "conventional" levels of a Canadian – 3.8 ha, of a Russian – 2.7 ha and of an American – 2.4 ha (The Soil Resources of Bulgaria, 1989; Teoharov, 2006).

3. Half of the fertile soils and lands are in Europe and North America. The other part is in Africa, Asia and Latin America, where almost 6 times more people live and there is almost the same share of fertile soils. At the same time, the fertile capacity in Africa is 7 times lower and in Asia it is twice lower. The conclusion is that countries with six times lower population are six times richer at birth. At the same time, in countries with a population 6 times more, the land potential is used from 2 to 7 times less.

Why food security problem ?

1. Because of shortage of food and consumption of less food and other products that are produced and manufactured.

2. This shortage leads to the use of natural resources and first of all of plant produced food, without solving the food shortage problem. It is known that for a year and a half soil, lands and plant resources are destroyed as big as the territory of the state of Bulgaria.

Why environmental problem?

1. Because of overloading and use of land resources and destruction of natural plant cover, irreversible soil degradation processes occur alongside threatening increases of carbon dioxide, reduction of organic carbon and disruption the exchange of soil carbon between soil and air, due to the climate change and increase of greenhouse gas emissions into the atmosphere.

2. Climate change and permanent disruption of mechanisms and systems in pedoclimatic, bio-productive and hydrodynamic processes.

3. Uncontrollable and unreasonable use of underground resources. (Just one example of our reality in Bulgaria: the demand for shale gas in the Dobrudzha Chernozem soil - a place, where there is no slate (shale), is contrary to all natural, geological, public and social laws).

These three problems are at the heart of the next two economic and social issues, which lead to a public crisis. Is there a solution? Yes, there is !

1. A real look at science, as the EC says, and the use of its innovations.

2. By preparing specialists and transferring ideas, think talks, funds and capital to the periphery of individual countries and from one point of the planet to another, by strictly observing international rights and agreements. Otherwise the issues will not be solved with aggression and wars, redistribution of land and human resources of the world.

3. Strict implementation of the Paris climate agreement and penalty procedures accompanied by international pressure in case that someone does not fulfill them.

The Modern Paradigm and the Three Maxims

In recent times, soil science has continued to be a major challenge for researchers and societies. Moreover, today, the triadic paradigms "soil-land-people" and "capital-labor-science" are complemented by another one - the new perfected paradigm: "reason-harmony-prosperity"), outlined in the study of the noosphere by Vernadski (2009), where the modern "geological" person is responsible for the future of the planet. If today's societies do not realize the need for cleanliness and health of soils, land and people, they will cease to exist. Three major maxims oblige us to work in this direction:

1. Soils, land and people need to think globally and solve problems locally because the potential of soil, land and human resources and the problems that exist in each country are different.

2. Care for the soil and the earth is care for the health of the people and future generations. Professor Justus von Liebig, the founder of organic chemistry, plant nutrition and soil fertility, says: "*Civilization develops and dies together with its soil.*"

3. Soil is a natural body and a major ecological resource that is usually associated with fertility quality and the functions it performs in nature. The most important role of soil is that of a living, biological system with enviable geological and historical memory, which creates material goods and preserves the archeological values of man. It is enough to make an archaeological (soil) profile in the center of Sofia to convince this new definition.

Something More and Unknown of Soils and the Earth.

In our country, care for the soils, land and people has not begun today. The first Bulgarian soil scientist, Nikola Pushkarov, wrote in 1909 the capital work "Soil Formation" and clarified the genesis and the laws of its formation, and in 1911 and 1931 respectively created the first Agro-geological Department for Soil Studies and the first National Soil Map. On December 14, 1930, scientists from the Faculty of Agronomy and Forestry and the Agricultural Bank of Bulgaria organized the first holiday of Bulgarian land, and one year later the best scientists and specialists developed a program for its management, which they devoted to the "*peasants – men, women, and children, who, from sunrise to sunset, infuse Bulgarian lands with their noble sweat.*" The same scientists and specialists turned with a proposal to the International Institute of Agriculture in Rome (now the FAO) to make this land celebration as much as possible a global and an international one. By its letter of March 3, 1931, the International Institute of Agriculture proposed the date of March 21, when the spring begins (Vassilev, 1932). All this was done at a time when the developed countries in Europe did not have a national soil map and a holiday of the land. **It is time to recreate this holiday again and to turn it into a week of Bulgarian land to be celebrated in conjunction with the World Soil Day.** Nowadays soil and earth must be seen in unity, and they need the utmost protection of society. The soils and the earth are national and ancient wealth, which guarantees the national security of a nation for ever and ever.

Geographical distribution of soils shows that Bulgaria is a unique soil museum. From 32 soil groups and 320 soil differences across Europe and the world, there are 24 soil types (groups) and 276 soil differences in our country. Our country has been a wide field for research work at national and international level. In the N. Pushkarov Institute three international meetings were held in 1980, 1981, 1982, at which the foundations, principles, rules and guidelines for the development of the World Reference Base for Soil Resources were outlined and Bulgarian Soil Science made a significant contribution to its creation (WRB, 2006). People in our state have highly appreciated the role of scientists, the importance of soils and soil fertility, even the name of some soils are connected with their lifestyle, culture, traditions, history and folklore. Several examples: The *Chernozems* - with the granary and the bread of Bulgaria; the *Gray-brown forest soils* - with the "wild" forests in Ludogorie and the lush meadows and pastures of the Fore-Balkan; *Cinnamonic soils* - with the preservation of the historical memory of several civilizations, the breeze of the south and

the southern fruits, the *Smolnitza* - with the snow-white cotton and the "black cotton soils", the *Brown forest soils* - with the sound of the beech trees and the song of the voivodes, the *Dark-colored soils*- with the evergreen coniferous forests and the clear spring waters, the *Mountain-meadow soils* with the Chiprovtsi carpets and Karakachan flocks, the *Alluvial and the Deluvial* soils of the bows and the colts - with the unsurpassed in color and sweetness fruits and vegetables, the amber grapes and the Red Bulgarian Rose, artistically depicted by a number of artists. Even the soils with a primitive and shallow profile are in areas with unique and whimsical shapes - red, yellow and colorful pyramids and rocky spaces, resembling a variety of images and shapes taken from the earthly world - from the beautiful Bulgarian to the fearless angry lion. The Bulgarian, historically, took special care to preserve and enhance soil fertility, and in this connection he always built his settlements on hilly terrains and at the foot of the mountains but not in the plains over fertile soils and lands.

However, the resistance and buffer properties of the Bulgarian soils have been decreased over time. The area of the so-called low-productive, degraded, primitive, shallow, eroded, disturbed, polluted, sealed, anthropogenic, technogenic, generally defined as "defective" or problematic soils, have increased every year (Koinov 1980; Ninov et al. 1982; Teoharov, 2003; Boyadzhiev and Teoharov, 2006; Rousseva et al., 2010). They are subjected to natural anthropogenic and technogenic pressure and irreversible processes - degradation, vegetation, erosion, acidification, salinisation, over-wetting, swamping, pseudo-subsoiling, demolition, geochemical loading, pollution, sealing, disturbance, plowing, seizure and total destruction of soils in construction works etc. These processes are responsible for the formation of different new soils and introducing some of them into the national and world classifications (Garbuche et al., 1975; Donovan et al., 1975; Penkov et al., 1992; Teoharov, 2006; FAO, 2006; Jeleva, 2010). It is our duty and responsibility to manage these processes, arising from their genesis and post-genesis, which generally affect soil and earth changes. Depending on these processes and changes and the constraints they create on soil fertility, certain groups and subgroups are formed.

I. Soil Influenced by Natural Hazards and Overloaded.

1. Acidic (medium, strong and very strong) soils. Their total area in Bulgaria is about 2 million ha, of which: 0.5 million ha with a very strong and highly acidic reaction and 1,5 million ha with a medium acidic soil reaction. 4,3 million ha are potentially susceptible to acidification. Solution: Melioration with gypsum and growing and acidophilic plants.

2. Salt affected (halomorphic) soils. Their total area is 55 000ha, of which 35500 ha have been salted by natural processes and 25 000 ha - by industrial and drainage activities. Solution: Melioration with chalk and growing of halomorphic plants.

3. Eroded soils - with a slope of over 3%. Their total area in the state is about 5,08 million ha, of which: 3.73 million ha of water erosion and 1.35 million ha of wind erosion. About 9.6 million ha have a potential risk of water erosion and about 0.5 million ha of wind erosion. There is no evidence of irrigation erosion. Solution: Application of organizational-economic, agro-technical management, forestry, hydro-technical methods, anti-erosion and bio-protection systems of agriculture.

4. Seasonal surface-waterlogged soils. Their total area is in the range of 0.45 to 0.55 million ha. Solution: Deep rupture and drainage (surface and indoor).

5. Swamp soils. Of these: 60 000 ha meadow swamps, 6 000 ha of peat bogs, 25000 ha drained and meliorated, which after 2-3 decades restored their original status due to unsupervised drainage channels. Solution: To preserve their environmental status in order to protect their ecological status. Afforestation with hydrophilic plants, drainage only in case of important case.

6. Podzolic soil. They have not been studied. They are spread in the Rila and Pirin mountains on northern exhibitions with coniferous vegetation on acid rock. Solution: Afforestation with acidophilic coniferous and broad-leaved vegetation.

7. Shallow high-carbonated soils. Their total area is 208 000ha of the Rendzinas soil type. They are formed on solid scales with more than 40% calcium carbonate in the rock. Solution: Growing of sweet-loving plants and use of weather-resistant pads in perennials

8. Deep carbonated soils. The total area is 626 000 ha of Calcic Chernozem subtype with more than 10% calcium carbonates. They are formed on soft carbonate rocks. Solution: Growing of plants with high carbonate resistance and use of rooted graftsin permanent crops.

9. Colluvialand proluvial (rocky) soils with a rock fragment content of over 30-40%. Solution: Stone cleansing and afforestation.

10. Shallow primitive soils with a rock landscape, with a depth of up to 10 cm and humus up to 1%. Solution: Afforestation.

II. Soils Influenced by Anthropogenic Pressure

1. Rigged soils. Their total area is 0.31 million ha. New soil cover is formed with an increased clay content, secondary carbonates and altered pH when it is mixed surface humus A horizon and illuvial subsurface horizon. Solution: Proper diagnosis and land evaluation, and appropriate selection for perennial crops.

2. Rice (sank) soils. Their total area is 11200 ha. Formed over soil with hydro-morphic character, secondary gally formation and acidification. Solution: Rotation of crops.

3. Hydromelinated (drained) soils. Newly soil cover is formed, which is mostly salted due to the high content of secondary water-soluble salts and exchangeable sodium. Solution: To preserve the status and ecological areal of swampy soils.

4. Burned soils. Typical of Bulgaria since 1989, after 2001 their area became about 130 000 ha. Annually, between 8,000 and 30,000 ha are burned. Decision: Adopting strong legislative measures.

5. Reclaimed soils. Their total area is 11 228 ha. Modern low productive soil from embankments and soil-geological substrates from industry is formed. Solution: Afforestation and cultivation of agricultural crops on flat terrains.

6. Degraded (artificially eroded, "beheaded") soils. They are formed at excavation of the soil at different depths in order to align the terrain, terraces, construction of motorways, railways. lines and more. The excavated ("buried") soils are formed from the excavated soil mass.

7. Buried soils. They are formed by overlapping (depositing and depositing) with other soil materials with a depth of about 50 cm above natural soils.

8. Contaminated Soils from manure. These soil are formed over unregulated dumps with manure. Solution: Construction of sustainable concrete bunkers, away from groundwater, wells and garden soil.

9. Contaminated soils from plant protection products (pesticides), growth regulators and other chemicals (insecticides, acaricides, fungicides, herbicides, zoocides, rodenocides, nematicides, limetites, defoliant, desiccants). Every hectare in Bulgaria is attacked with at least 250 g of pesticides. Solution: Creation and use of plant extracts and natural products to combat plant diseases and pests; mechanical, physico-mechanical, biological methods of plant protection; sanitary control of soil, crops and food production.

III. Soils Influenced by Urbanization, Recreational, Technogenic and Industrial Activities and Pressures. Total area of about 404 000 ha.

1. Contaminated soils. The total area is 99 400ha.
 - With heavy metals from the industry in agricultural territories – 44 000 ha, of which 8160 ha with pollution 3 times above the limit value.
 - With heavy metals from industry in non-agricultural territories – 43600 ha
 - With radioactive elements – 1000 ha.
 - With petroleum products – 130 ha.
2. Degraded soils. Their total area is 95543 ha.
 - Mining and landfills for industrial waste – 32 144 ha.
 - From industry and energy production - 65397 ha.
3. Quarry and stone pit. The total area is 3800 ha and 5800ha.
4. Sealed soils. The total area is about 396 000 ha
 - Urbanization and infrastructure – 348 000 ha..
 - In recreational areas - 47871ha.

Solution: Construction of new roads and highways at the foot of hill and mountain terrains, technical and biological reclamation of the lands, remediation and bioremediation of the soil and extension of soil-ecological monitoring. To conduct soil research using *cathena* method and geo-ecological soil profile. To improve all legislation acts connected with soil protection.

Actual Issues Related to Arable Land and Soil

Bulgarian Ministry of Agriculture and Food (MAF) statistics show that arable land and soil in the country is about 5.09 million ha. According to the data of N. Pushkarov Institute, they are 4 827 785 ha. By comparison, according to Academician Stranski, in 1939 they were 3 907736 ha. The increase of the agricultural lands before 1989 is due to the consolidation and melioration of the soils and lands, and after that date due to the inaccuracies and the legal inscription through declarations after the changes in 1990. At present time, 3.49 million ha are actually cultivated. An agricultural-environmental problem is dualism in land use, namely the over-fragmentation of the land of about 19.5 million landed properties and its over-concentration in tens of thousands of acres. Separately, according to former agriculture minister Nihat Kabil, the land of 340,000 owners was on the different levels of the judiciary system. All this makes it difficult: 1. To apply scientifically based systems of land use and production, adapted to the agro-ecological regions of the country; 2. To ensure proper organization and farming in the agricultural territories; 3. To build and establish fair land and lease relations with sustainable socio-economic and environmental benefits (Stoynev, 2004, Teoharov, 2006, 2011, Hristov, 2017). With a

reference to that, some basic and imposed harmful processes in agricultural practice that are directly related to the management and conservation of soil and land resources deserve attention such as:

1. Non-application of the agro-ecological-scientific approach in agriculture and ignorance of the agro-ecological regions in the country.
2. Non-application of minimal treatment to soil diversity and agro-ecological conditions.
3. Incorrect soil treatment and mixing the humus horizon (surface) with the illuvial - clayey (horizon) horizon.
4. Vertical soil cultivation in perennial arrays and acceleration of erosion processes.
5. Deterioration of soil properties due to additional compaction by super-heavy agricultural machinery.
6. Non-maintenance of soil fertility and deterioration of land and social life of landowners due to unsettled land property and difficult access to it.
7. Bad rotation of crops and application of monoculture agriculture.
8. Unbalanced fertilization and nutrition regime of crops with consequent acidification of soils.
9. Exclusion from farming systems of microbial fertilizers, organic fertilization and sideration as the main organic (biological) methods for maintaining and increasing soil fertility.
10. Implementation of construction and industrial activities in areas with high soil fertility and lands up to the 3rd land category.
11. Use of high-yielding soils and land for road infrastructure rather than the foothills of the mountains and slopes.
12. Damage and contamination of soils and lands from agricultural areas and appearance of new pollution "hot" points.
13. Non-maintenance of open and closed irrigation systems and channels and appearance of new "cold" swamp points.
14. Impaired natural-biological basis of agricultural production (land, agricultural crop animals), which is why there is an imbalance between plant and livestock.
15. Creation of unproven state and private structures for development and implementation activities related to the management of soil and land resources.

A significant part of the afore mentioned problems and weaknesses, albeit with a delay, were also noted in the report of the European Parliament and the European Commission of Agriculture and Rural Development on 30.03.2017 with subject "The Current Situation in Relation to the Concentration of Land: How to Facilitate Farmers' Access to the Land ". The report was drawn up on the basis of: 1. Opinion of the European Economic and Social Committee of 21.01.2015; 2. Guidelines on Responsible Management of Land, Fisheries and Forestry Rights of the World Food Security Committee on May 12, 2012; 3. Petition 187/2015 of the European Parliament regarding to: Protecting and managing European agricultural land as a common good: Calling on civil society organizations for a sustainable and fair EU land policy; 4. Survey on the theme "The amount of agricultural land grab in the EU" of the Committee on Agriculture and Rural Development of the European

Parliament; 5. The infringement procedures which the Commission is planning or has already instituted against the Member States, among which Bulgaria is on first place.

Considering that:

1. The agricultural areas used by family, small and medium-sized agricultural holdings are of particular importance for water and climate management, carbon balance and for the production of healthy food, as well as for biodiversity, soil fertility and conservation the landscape; 2. 20% of agricultural land is adversely affected by climate change, soil erosion due to floods, winds and poor management; 3. Loss of agricultural land caused by conflicts of access and use, concentration of land in large farms and non-agricultural investors, deteriorated land and lease relations,

in its report of the European Parliament:

1. Encourages the EU Member States to "step up their efforts to transfer knowledge through research and innovation projects to improve soil quality through the application of agro-ecological practices".

2. Calls on the Commission to "analyze the risks posed by land concentration to the environment, soil quality and rural development".

3. Within the framework of integrated land management, local and regional conditions in the agglomeration programs of the parcels of agricultural land, respectively agro-ecological ones, should be taken into account.

4. Reaffirms the Commission's statement that "land is a scarce resource subject to strong pressures from climate change, soil erosion and over-exploitation or land-use change".

5. Supports environmental and social measures for the protection of the land, while stressing that it is the responsibility of the EU Member States.

6. Proposes that direct payments be received on the basis of environmental, socio-economic and societal benefits, and caps should be set under the Common Agricultural Policy and the direct payments corrected scheme.

7. Recalls the positive measures taken by some EU Member States to regulate their land markets in order to avoid speculative transactions in the land sale and purchase.

8. Calls on the EU Member States to support or create appropriate institutions with state participation and public oversight of land management.

9. Calls on the EU Member States to prioritize small and medium-sized local producers, new entrants and young farmers, special support for small and medium-sized individual farms and cooperatives for young people and women, as they preserve the cultural heritage and support rural and social life in them.

10. Encourages EU Member States to prioritize family farms and sustainable production methods as they play an active role in the economic structure of rural areas by ensuring a wide distribution of land ownership.

11. Encourages EU Member States to use such land-based land-use instruments already successfully used in some countries, namely: "State licensing of land sales and leases, land-use obligations by landlords, restrictions on the right of purchase by legal persons, the upper limit of the hectares that can be redeemed".

12. It is stated that land, its governance and urban development rules are the responsibility of the EU Member States and therefore urges them to take into account, in their public policies, the protection and importance of farmland as well as the transfer of land.

13. Stresses that ownership is the best prerequisite for responsible soil management and sustainable land management. In this respect, it introduces the notion of "active farmer".

14. Points to the large concentration of land and financial resources in large farms and non-agricultural investors, which distorts production and market processes.

Conclusion

Soil and land management for the benefit of people is definitely a European theme. The main reason is that "the concentration of agricultural land and financial resources in the hands of a small number of operators is linked to a significant social, cultural, economic and political impact over EU Member States". The data from 2010 show that in the EU, 3% of farms already control 50% of the utilized agricultural area. On the other hand, in 2012, 80% of the farms had only 12% of the agricultural land in EU states. The European Parliament notes that the scope and rates of concentration of land are alarming. Therefore, in its motives, the EC defends the future development of multifunctional agriculture, small and medium-sized farms, especially family and co-operative farms. The EC concludes that "both the concentration of financial assets and too much concentration of farmland divide society, destabilize rural areas, jeopardize food security, and thus the environmental and social goals of Europe." The conclusion is that the conservation and enhancement of the fertility of continental soil and land in Europe are under threat.

Over the past 28 years, scientists from the "N.Poushkarov" institute have constantly reminded the public and the state institutions about the current problems related to the management of the soil and land resources and the mistakes in the implementation of the land and agrarian reform. Now this question is a European topic, the right solution is found, and the most appropriate thing is to apply the knowledge of soil and agrarian science and to change and apply the legislation.

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Criteria for Identification and Diagnostics of Sandy Soils in Bulgaria

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Abstract

The present article considers the criteria for diagnostics and identification of sandy soils in Bulgaria. The research so far has proved that they have a soil profile structure of the type A-AC-C, sand content over 75% in the surface horizon and of 80-90% in the soil formation rock. With some exceptions they are non-fragmented soils. The humus content most often varies from very low to low and average by way of exception. The total content of iron is most often low and in isolated cases it is higher, which could be considered as an exception, too. The soil reaction is slightly acidic to slightly alkaline. The relative and volumetric density are high and very high and the general porosity vary from low to average. According to the water-physical indicators these soils are hydrophilic and very rarely - hydrophobic. The carbonate variation determines to a greatest extent the Sandy soil classification on a lower taxonomic level. The sorption capacity is low to average while the base saturation is high. The content of primary minerals is inherited and is determined by quartz and feldspars. This defines sandy soils as primitive ones with underdeveloped soil-formation process.

Keywords: Sandy soils, origin, diagnostics, criteria for identification, classification.

Introduction

In recent years Sandy soils in our country have been an object of research for some Bulgarian scientists (Teoharov, 2003, 2004; Ninov, 2009), who have provided information about their definition, diagnostic evaluation and classification. New data have been obtained from additional research of (Teoharov, Kirilov, 2011, 2012, 2013) about the morphogenetic characteristics of Sandy soils and about their physical, physico-chemical and general chemical indicators as well. Both research scientists note that these soils have been formed on soft rocks of marine origin from natural grass and shrub vegetation. A substantial part of the soils have been subjected to cultivation due to the fact that they are suitable for growing agricultural crops. Active resort tourism is developing in regions where Sandy soils are spread, which is why they are often sealed by new construction of buildings, roads, highways and railway tracks.

Materials and Methods

Data from different stages of research along the Danube river and the Bulgarian Black Sea coast have been used to establish the criteria and diagnostics for identification of Sandy soils. Besides the thorough geo-morphological and morphological, research analytical results of different diagnostic indicators have been provided.

Analyzing the soil samples was performed according to the following indicators, criteria and methods:

Morphological description and characteristics (Penkov et al., 1992), Guidelines for Soil Description); Mechanical content (Kachinski, 1958); Soil Colour (according to the Munsell color scale, Soil Color Charts, 1975); Volumetric Density (Kachinski, 1965); General Porosity by Calculation (described by Penkov et al., 1981); Hydrophobicity and Hydrophilicity of Soils (Doerr, 1998); Total Carbon by Turin (Kononova, 1963); Humus by Calculation %C. 1,724; Total Nitrogen by Keldal (described by Penkov et al., 1981); Composition of Humus by Kononova-Belchikova (Kononova, 1963; Filcheva&Tsadilas, 2002); Carbonates by the Method of Sheibler (described by Penkov et al., 1981); Sorption Capacity, Exchange Cations and Degree of Base Saturation (Ganev, Arsova, 1990); Microbiological Characteristics (Mishustin, Emtsev, 1989).

Indicators and Criteria for Definition of Sandy Soils

For the first time in Bulgaria Sandy soils were correlated by FAO and were called Arenosols by Mihailov, Teoharov (1985) and these soils were later mentioned in the monograph "Geography of Bulgaria" by Ninov (1997). In the recent years the current problems in the classification of Bulgarian soils have been thoroughly analyzed by Teoharov (2003). He has pointed out the lack of data about Sandy soils as a disadvantage of Bulgarian classification - (Arenosols, WRBSR, 2014) and he has also emphasized that Sandy soils do not have their position in the classification as a separate soil type. Kirilov, Teoharov (2011) clarified the morphogenetic diagnostics of Sandy soils along the Bulgarian Black Sea coast. The processes of humus formation on modern and older marine terraces in regions along the Black sea coast have been described in detail (Kirilov et al., 2012). The sorption, acidic-neutralizing and hydrophobic properties of Sandy soils have been proved and their physico-chemical characteristics have been established (Atanasova et al., 2013). Land evaluation of Sandy soils in the region of the northern and southern Black sea coast has also been made with regard to the needs of basic agricultural crops and reference to climatic conditions. The land evaluation was accomplished by using "Methods for Relative Evaluation of Agricultural Lands in Bulgaria" (Krasteva et al., 2013).

The research so far shows that in the first detailed study of Sandy soils, performed by Mihailov, Teoharov (1985) there are analytical data of the genesis and diagnostics of these soils in the Gamza area (the region of Vidin). The authors pointed out the basic diagnostic criteria, which include the structure of the soil profile of the type A-AC-C, the high content of sand, the low humus content and the comparatively low sorption properties. These soils were described on sand sediments in the region along the Danube river and were defined as underdeveloped Sandy soils (Arenosols). The authors provide their basic characteristics and soil-morphological description as follows: the soils under research were formed on loess-like

alluviums of very light (sandy and clayey-sandy) mechanical composition. The lightest and most coarse-graduate are the materials (gravel) composing the lower sections of the "C"-horizon. Mihailov (1988) noted that on different-age terraces mainly soils of underdeveloped profile - profile A-C, A-AC-C and A-(B)-C - have been formed and in morphological terms these soils show certain similarity as follows: they are characterized by a thin surface "A" horizon (20 to 25 cm), which in the lower part of the relief turns into a "aC" horizon (up to about 40 cm) and on the hump and the comparatively leveled parts it passes into a "C" horizon, then, with a distinct transition or abruptly, turns into the slightly distinct "B" horizon. This fact shows that Sandy soils pass into carbonate Chernozems or into the two other carbonate soil types. Carbonates are found on the surface or they are deposited at different depths in the "Ck" horizon. The data of the composition of the primary minerals show that the type composition of the primary mineral association is identical. The observed minerals, the morphological characteristics, the intensity of the marked weathering process, the quantitative distribution of the separate profile depths representatives are identical, too. All this is an indicator of the similar conditions of development of the soil formation process of the Sandy soils and the carbonate Chernozems in spite of the differences of the terrace levels, which is a proof that the differences in time of formation are minimal and not having any crucial importance.

However, in one case a soil of a primitive profile has developed and in the other the soil is characterized by a well-developed profile and "B" horizon. The soils have slightly acidic to slightly alkaline reaction and non-washing water regime. Under such conditions mineral phases are stable, especially quartz. The lack of differentiation in the profile of the studied soils is virtually connected with the lack of clay-formation, for which there are no conditions and the quantitative presence of primary mineral components, which are most rapidly disintegrated to secondary minerals is rather scarce. This is another indication that from a genetic point of view these are relatively modern soils. The soils under research are very slightly stocked with organic substance (about and less than 1%). As far as the humus is concerned they fall into the fulvic-humic type of humus. The humic acids are entirely connected with calcium. The content of mobile iron increases with the increase of soil dispersion, which is related to the increasing content of iron-containing minerals and it is in close relation to the content of organic substance. Mihailov, Teoharov (1985) suggest that on the basis of the entire information from the accomplished research, in relation to genesis, physic-chemical characteristics and the justified diagnostic criteria, it is appropriate to differentiate Sandy soils on a separate taxonomic level.

In the region of the town of Varna Teoharov's research of the geomorphology of two catenas of second order has provided new results and has contributed to the previous research performed of almost the same indicators of Sandy soils, which has simultaneously confirmed the criteria pointed out for identification of the studied soils.

A newer problem development of Primitive soils concerns the diagnostics and classification of Primitive soils in Bulgaria (Boyadziev, Teoharov, 2005). This study has analyzed and described all groups of Primitive soils, which are characterized by profile depth of 2 to 30 (40) cm; more than 15 % of fine earth, more than 40% of CaCO_3 in the surface 30 cm, a light humus horizon and different composition (sandy, sandy-clayey, clayey).

For the physic-chemical diagnostics of Sandy (underdeveloped) soils (Arenosols) done on the northern Black Sea coast (Teoharov, 2004) profiles from the land of the village of Vinitza and the Botanical garden of “St. St. Kliment Ochridski” University of Sofia near Varna were used. The morphological and physic-chemical properties were described with an evaluation that uses the degree of base saturation according to FAO (1988). In this respect they were classified as Calcaric (carbonate) Arenosols.

Kirilov, Teoharov (2013) have presented their diagnostics arguments for the introduction of Sandy soils as an independent soil type in the National Soil Classification. For that purpose the authors use some soil indicators and criteria, as follows: the soils of research are formed on soft, unconsolidated Palaeogene, Miocene and modern marine depositions with a sandy texture and composition and surfaces of flat, sloping and hilly relief. The soil-formation rocks have a direct impact on the processes of weathering, soil formation and soil diversity, but always within the limits of the studied Primitive sandy soils. Anthropogenic influences on soils directly affect the processes of their formation and degradation. The authors emphasize that in some areas of the Black Sea coast the soil formation has taken place in conditions of afforestation with different ornamental and natural forest plant species, while another substantial part of the soils has been conserved under asphalt, concrete and buildings. Some profiles from villa and garden areas have been investigated in conditions of soil cultivation by applying sustainable agricultural practices.

According to the research done by Kirilov and Teoharov Sandy soils contain more than 75% of sand in their surface horizon and over 80-90% of sand in the soil-formation rock. As a class of mechanical composition sandy and sandy-clayey soils have been evaluated. Soils formed on more modern marine (off-coast) depositions appear to be of lower class while soils formed on Miocene depositions are of a higher class.

It has been established that Sandy soils have comparatively poor general physical properties. According to the water-physical indicators they are hydrophilic. The sandy soils from the land of Aksakovo and Primorsko on the Black Sea coast are an exception due to dominant hydrophobic organic compounds such as alkanes and fatty alcohols, which determine the soils as less water-permeable and as having deteriorated water and air properties.

The humus content most often varies from very low to low and rarely to average, which is why the processes of humus formation and humus accumulation are at an early stage. The soils have similar values of the type of organic substance which proves the direct dependence of the soil-formation rock on the accumulated high-quality (of the mull type) humus. The correlation C:N and the humus content of the type humatic, fulvic-humate and humate-fulvic also confirm the potential opportunities of forming organic substances of high molecular weight and high-quality humus of the type calcium mull humus as well as the opportunity of structuring.

The iron content also proves incipient and modern processes of soil formation. The general and exchange iron is low and it is accumulated in the surface horizons as a result mostly of the increase of the γ_1 -fraction in the “A” humus horizon. In the soils around and in near proximity to the coast and the lowering terrains due to the processes of increased humidification and weathering the content of general and exchange forms of iron is

substantially increased and iron, as well as the increased amount of water-soluble alkaline salts, cause a harder internal structure of soils.

The soil reaction is slightly acidic to slightly alkaline (from 6 to 8.6). As far as the carbonate content is concerned these soils are non-carbonate, poor carbonates, average carbonates and rich and very rich carbonates – from 0 to 32% (in the C horizon). The sorption capacity varies from low to average (4 – 23,2 cmol_ekg /100g soil). The soils are from slightly to moderately colloidal, saturated with a high degree of bases, but incorrectly structured.

Sodium cation and water-soluble salt content has been found out in the region of Bourgas salt-pans, where the data show that it is higher. The degree of salinification does not exceed 20% and it often reaches 5%. The studied soils are defined as slightly salinificated.

The composition of the primary minerals is determined by quartz and feldspars. The formation of non-clayey minerals from the calcite group in some profiles proves the formation of non-clayey minerals and weak soil-formation (clay-formation) and the ability of these soils to structure in natural conditions. Primary materials have been inherited from sandy marine depositions. Quartz is a dominant mineral in all profiles and horizons and that fact defines the primary character of the soil-formation process.

The micro-flora is poorly developed and its amount is typical of Primitive soils. There is a higher amount of bacteria and oligonitrophils in the surface horizons, which is directly proportional to the higher humus content. The values of the microbiological indicators are dependent on the exposition of the micro-slope in soils formed on some southern micro-slopes and lower parts of the micro-catenas, and there is a definite tendency of the increase of values in the surface horizon. A tendency of higher biogenicity of the soils from the southern Black Sea coast is noticed in comparison with soils from the northern Black Sea coast. Land evaluation shows that in regard to the crops it was made for, the differences are substantial when the soils are compared to zonal Chernozems. Sandy soils are absolutely unsuitable for soya, less suitable for sunflowers, tobacco, apples and plums whereas in regard to vines the soil suitability is almost equalized.

According to the determined peculiarities of soil formation, the accomplished characteristics and diagnostics of the studied soils, they are classified as follows: Azonal, Sand, Underdeveloped soils of the following subtypes: carbonate, saturated, hydrophobic and slightly saturated. Under the FAO classification they are classified as Arenosols, with a subclass prefix Hydrophobic and Haplic and suffix subclass as follows: Hydrophobic eutric, Hydrophobic calcaric, Haplic eutric, Haplic calcaric, Haplic Hyposalic (Kirilov, 2013).

Conclusion

Based on complex field, geo-morphological, morphological, laboratory and analytical investigation and research the criteria for diagnostics and identification of Sandy soils can be characterized as follows:

1. Primitive and underdeveloped profile of 20-30 to 50 and rarely 60 cm of the type A-C and an initial degree of soil-formation (clay-formation).
2. Soft modern and old soil-formation rocks, most often of marine origin.
3. Content of sandy fraction over 75% in the A horizon and over 80-90% in the soil-formation rock.

4. Incipient processes of humus formation and humus accumulation and low content of humus substances of not more than 2 %.
5. Slightly acidic to slightly alkaline reaction (from 6 to 8.6).
6. High volumetric and relative density, respectively over 1.4 and 2.6.
7. General porosity – slightly or averagely porous (from 30 to 60%).
8. High content of inherited soils and low content of secondary (clayey) minerals.
9. High content of secondary (non-clayey) minerals from the calcite group in some varieties.
10. High salinification (up to 20%) in some varieties.
11. Availability of high hydrophobicity and rarely of high hydrophilicity, which is due to hydrophobic organic compounds of the type of alkanas and fatty alcohols.
12. Low to average sorption capacity (4 – 23,2 cmol_ekg /100g soil and high to very high base saturation (75-100%).
13. Calcium mull humus, humatic, fulvic-humatic and humatic-fulvic type of humus.
14. Low degree of feritization and absence of processes of rubification.

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Natural Radionuclides in Soils from Selected Regions in Bulgaria Affected by Natural and Anthropogenic Processes



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Abstract

The content of natural radionuclides ^{40}K , ^{235}U , ^{238}U , ^{232}Th and ^{226}Ra in soils from two regions of past uranium mining in Bulgaria were determined and analyzed and results of radiation monitoring summarized. Soil samples from three other regions in the country: North Bulgaria - plane region (around "Kozloduy" Nuclear Power Plant and the Danube River) – 40 samples; semi-mountainous - (Sofia field) – 5 samples and South Bulgaria – mountainous (Rhodope massif) – 25 samples, were analyzed for comparison.

Evaluation of possible radiation hazard to the population in the respective regions was made by calculating the average radium equivalent activity (R_{eq}) and the external hazard index (H_{ex}). It was found that content of natural radionuclides in the studied soils, both plain and mountainous, is within normal background levels and is not hazardous to the population.

Key words: radionuclides ^{40}K , ^{235}U , ^{238}U , ^{232}Th and ^{226}Ra , radiation monitoring of soils, radioecology

Introduction

Anthropogenic impact on environment has severely increased in recent decades leading to serious ecologic problems. Areas affected by mining industry which are highly contaminated are of particular interest due to the hazards for human health and the state of the landscape. Such is the catchment area of the left tributary of the river Taina, municipality of Novi Iskar, where underground and open uranium mining were carried out in the "Iskra" section and the area along Mesta river valley around Eleshnitsa mine. (Misheva at al., 2009, Yordanova at al., 2011 a, Filchev and Yordanova, 2011, Yordanova at al., 2015)

Water catchment of the river Taina occupies an area of 4,775 km². The altitude of the catchment varies from 500 m at the flowing in the Iskar river to 964 m in the highest part of the catchment area. The main soil types in the area of research are leached Cinnamonic forest soils - 45.8% and Brown forest soils -36.37%. The remaining 17.4% of the catchment is covered with Anthropogenic soils, reflecting mainly the human impact on the river basin.

The village of Eleshnitsa is located 12 km North-east of Bansko at the southern foot of North-west of the Rhodope massif "Belakite" along the two banks of Zlataritsa river lower stream. The river Zlataritsa flows into the Mesta river, which passes near Eleshnitsa. Warm air from Aegean Sea passes along Mesta valley.



Fig. 2. Engineering activity on the closure of Eleshnitsa Mine

Both the Belakis and other surrounding mountain massifs and plane areas are covered with pine trees and partly with beech and oak forests. The land of the village is relatively large. It covers about 300 km² of predominantly mountainous and semi-mountainous area. To the west and northwest it is bordered by the land of the village of Babiak, to the north by Gul-tepe peak, and to the East and Southeast by the land of the villages of Gostun and Obidim. The Mesta river and the land of the town of Dobrinishte and the town of Bansko serve for south and southwest border respectively.

In Eleshnitsa, mining was carried out under the classical method. In plant “Zvezda” only flotation was carried out and the enrichment in Buhovo.

The objective of the present study was to determine the content of natural radionuclides ⁴⁰K, ²³⁵U, ²³⁸U, ²³²Th and ²²⁶Ra in soils from the two regions of past uranium mining in Bulgaria – “Iskra” section, Novi Iskar and Eleshnitsa and to evaluate possible radiation hazard to the population in these regions.

Materials and Methods

Soil samples from 10 points in the area of the river Taina, Iskra section, and 11 points along Mesta river valley, Eleshnitsa mining area, were collected and analyzed.

Soil samples from three other regions of the country: North Bulgaria – plain area (around Kozloduy Nuclear Power Plant and along the Danube River) - 40 samples; semi-mountainous (Sofia field)- 5 samples and South Bulgaria - mountainous (the Rhodope massif) –25 samples, were also taken and determined for comparison. Collection and preparation of samples was carried out in accordance with BDS 17.4.5.01 and ISO 18589-2. Soil samples were homogenized, dried at 80 ° C and crushed through 2 mm sieve. They were analyzed for contents of natural radionuclides ⁴⁰K, ²³⁵U, ²³⁸U, ²³²Th and ²²⁶Ra in the Testing Laboratory of Radioecology and Radioisotopic Research at ISSAPP “N.Pushkarov”. The laboratory has been accredited by EA “BAS” under BDS EN ISO / IEC 17025: 2006 since 2002, and it has been declared by the Ministry of Agriculture and Food as National Reference Laboratory in the field of radiometry since 2007. Validated interlaboratory methodologies were used (Naidenov et al., 2001).

Activity concentration of natural ^{238}U , ^{226}Ra , ^{232}Th and ^{40}K in soil samples was determined by gamma-spectrometric analysis with Multi Channel Analyzer DSA 1000, CANBERRA, and ultra-clear Ge detector. Measurements were carried out according to the requirements of ISO standard 18589-3, using gamma spectrometer with a pure Ge detector with 20% efficiency and 1.8 keV resolution for the ^{60}Co line of 1332 keV energy. The credibility of results is confirmed by regular interlaboratory comparisons and proficiency testing schemes. The time for measuring one sample varies between 19 and 24 hours.

^{226}Ra was determined by the full energy absorption peak of 186.3 keV, with correction for ^{235}U (185.6 keV). Activity of ^{238}U was determined by daughter product ^{234}Th (63.3 keV and 92.3 keV). Gamma-lines of ^{228}Ac (911.0 keV) and ^{208}Tl (583.3 keV) were used for ^{232}Th .

Results and Discussion

Figures 1 and 2 present the results from the analyzes of the content of natural radioactive elements ^{40}K , ^{235}U , ^{238}U , ^{232}Th and ^{226}Ra at 10 points of Taina river area and 11 points along the Mesta river in Eleshnitsa mining area.

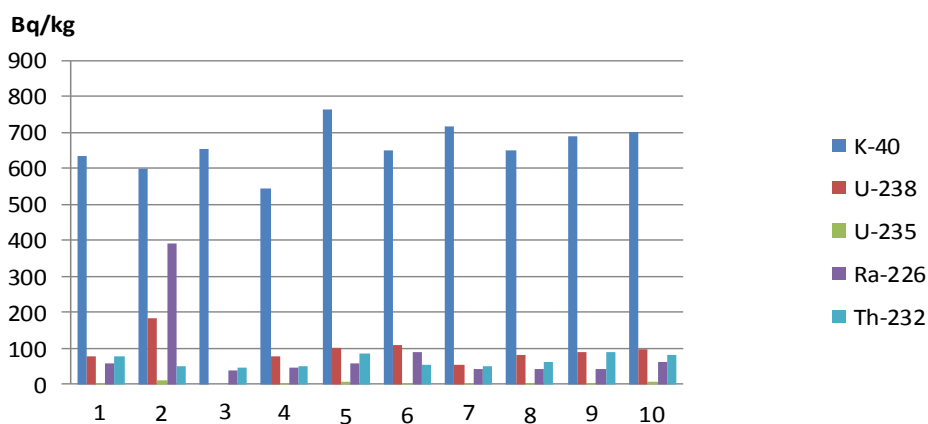


Fig. 1 Content of ^{40}K , ^{235}U , ^{238}U , ^{226}Ra and ^{232}Th in soil samples from 10 points in the area of the river Taina.

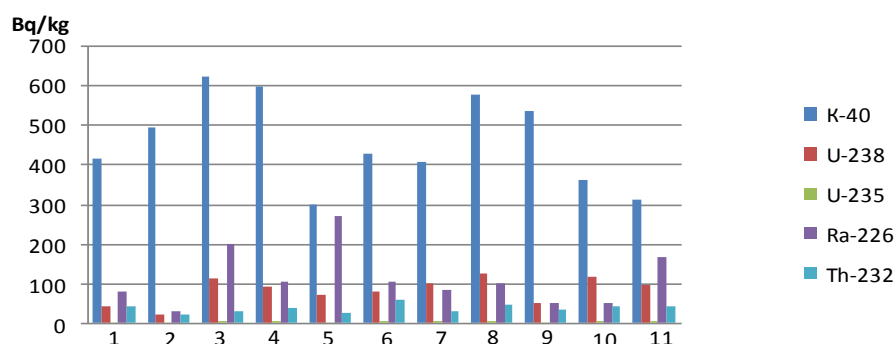


Fig. 2. Content of ^{40}K , ^{235}U , ^{238}U , ^{226}Ra and ^{232}Th in soil samples from 11 points along the Mesta river valley, Eleshnitsa mining area.

The average results from the analysis of natural radionuclides contents in the soils from separate areas of research are presented in Table 1. The standard deviation obtained is presented in absolute terms and percentage in brackets.

Table 1. Average values of natural radionuclides content in soils from five regions of the country in Bq.kg^{-1} dry weight.

	^{238}U [Bq.kg^{-1}]	^{226}Ra [Bq.kg^{-1}]	^{232}Th [Bq.kg^{-1}]	^{40}K [Bq.kg^{-1}]
North Bulgaria (plane area)	33±8(24%)	32±10(31%)	34±9 (26%)	456±106(23%)
Sofia field (semi-mountainous)	26±11(42%)	31±10(31%)	40±11(27%)	447±97(22%)
South Bulgaria (Rhodope mountain- mountainous)	62±24(39%)	46±22%(48)	58±16(27%)	686±215(31%)
Mesta river valley(Eleshnitsa mining area- semi-mountainous)	73±23(31%)	51±17(33%)	57±16(28%)	735±122(16%)
River Taina catchment, “Iskra” section	98±35(36%)	35±20(57%)	37±20(54%)	458±108(24%)

Values presented in the table for radionuclides studied correspond to average values characteristic for the latitude of Bulgaria estimated and reported by International Atomic Agency, Vienna (UNSCEAR, 1993, Kinova, 1997, Yordanova at al., 2005, Yordanova at al., 2011 b). The average values reported are 40 Bq.kg^{-1} dry weight for ^{238}U , ^{226}Ra and ^{232}Th , and 580 Bq.kg^{-1} for ^{40}K respectively. Slightly higher values found in Rhodope mountain and Mesta river valley are due to the presence of rocks as gneiss, shale, granite, etc. with higher content of natural radionuclides on which soils in the area have been formed (Montes. et al., 2012).

Evaluating radiation hazard

Radium equivalent activity index (Ra_{eq}) and external hazard index (H_{ex}) were used to evaluate the results obtained in terms of radiation hazard to the population in the areas of research.

Radium equivalent activity was calculated by the following formula (Beretka, Mathew, 1985):

$$Ra_{eq} = A_{Ra} + 1.43A_{Th} + 0.077A_K \quad (1)$$

Where A_{Ra} , A_{Th} and A_K are the activities in Bq.kg^{-1} of ^{226}Ra , ^{232}Th and ^{40}K , respectively. The calculation is based on the assumption that 370 Bq.kg^{-1} of ^{226}Ra , 259 Bq.kg^{-1} of ^{232}Th and 4810 Bq.kg^{-1} of ^{40}K produce the same gamma-ray dose. The limit value is 370 Bq.kg^{-1} .

External hazard index was estimated by the following formula (Krieger, 1981):

$$H_{ex} = A_U / 370 + A_{Th} / 259 + A_K / 4810 \leq 1 \quad (2)$$

Where A_U , A_{Th} and A_K are the activities in $Bq \cdot kg^{-1}$ of ^{238}U , ^{232}Th и ^{40}K respectively. The results obtained are presented in Table 2.

Table 2. Average values of $Ra_{eq} [Bq \cdot kg^{-1}]$ and H_{ex} in soils from the five regions of the country

	Ra_{eq} $Bq \cdot kg^{-1}$	H_{ex}
North Bulgaria(plane area)	115.73	0.31
Sofia field (semi-mountainous)	122.62	0.32
South Bulgaria (Rhodope mountain- mountainous)	181.76	0.54
Mesta river valley (Eleshnitsa mining area- semi-mountainous)	189.10	0.57
River Taina catchment, "Iskra" section	123.45	0.49
Maximumvalue	370	1

The values of the radiation hazard evaluation of gamma background resulting from natural radionuclides content in the soils from studied areas confirm the population safety from radiological point of view.

Conclusion

Content of natural radionuclides ^{40}K , ^{235}U , ^{238}U , ^{232}Th and ^{226}Ra in soils from two regions of past uranium mining (Iskra section, Novi Iskar and Eleshniza, the Mesta river valley) were determined along with soil samples from three other regions of the country used for comparison. Results of radiation monitoring in the five regions of study were summarized. Values for natural radionuclides under research correspond to average values characteristic for the latitude of Bulgaria reported by the International Atomic Agency, Vienna. Slightly higher values found in the Rhodope mountain in south Bulgaria and Mesta valley are due to the presence of rocks as gneiss, shale, granite, etc. with higher content of natural radionuclides on which soils in the area have been formed.

The radium equivalent activity index (Ra_{eq}) and external hazard index (H_{ex}) indicate that the contents of the natural radionuclides in soils from the studied regions, both plane and mountainous, is within the normal background quantities and does not pose radiation hazard to the population.

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Horizon Differences in Micronutrient Contents of Soils of the Coastal Plain Sands in Imo State, South-East Nigeria, Micronutrient Contents of Pedons formed under Coastal Plain Sands



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Abstract

Horizon differences in soils influence ability of crops to obtain nutrients and indeed support other uses. The study aimed at investigating the micronutrient (Cu, Mn, Fe, Zn) contents of horizons of two different pedons which lies on similar parent material (Coastal plain sand) in Imo State. Random survey technique guided by the geologic map of the area was used in siting one profile pits on each of the locations. The profile pits were described; and identification and delineation of horizon boundaries were accomplished using FAO guidelines before actual sample collection for laboratory analyses. Soil data were subjected to coefficient of variation (CV) analysis. The results of the micronutrients indicated range values of 0.02- 0.36 mg kg⁻¹ for Mn, 36.6-108 mg kg⁻¹ for Fe, 0.091-0.256 mg kg⁻¹ for Cu and 0.205-0.774 mg kg⁻¹ for Zn in pedon 1. In pedon 2, the ranges were 0.13-1.09 mg kg⁻¹ for Mn, 19-50.6 mg kg⁻¹ for Fe, 0.143-0.613 mg kg⁻¹ for Cu and 0.22- 0.962 mg kg⁻¹ for Zn respectively. The values of Zn, Cu and Mn were below the critical limits recommended for arable crop production. However, Fe concentration was generally high in all the horizons and was above the critical level recommended. Hence, the soils were surplus in iron but deficient in Cu, Mn and Zn. It is therefore recommended that agronomic requirements should consider these essential edaphic attributes in the study area.

Key words: Coefficient of variation, Critical level, Horizon, Nutrient, Profile pit

Introduction

Micronutrients assessment has been on the forefront of recent researches with findings that indicated increase in their deficiency. Information on variations of soil micronutrient with soil depth will enable potential land users to appreciate its behavior on various soil types, so that they can be managed appropriately to derive optimum crop productivity. Several researchers have reported on level of micronutrients on soils of the basement complex rocks (Kparmwang et al., 1995, 1998; Oyinlola and Chude, 2010) and also on sedimentary soils (Kparmwang and Malgwi, 1997). Also, Rengel, (2007) and Alloway, (2008) have observed that millions of hectares of arable land in the world are micronutrients

deficient. Many of these deficiencies are in relation with increased demands of available forms of micronutrients by rapidly growing crops.

The essential need for micronutrients must always be considered as these makes enormous contribution toward the plant and microbial growth. The excess of micronutrients in the soil brings about nutrient antagonism, inhibition in plant uptake of some major nutrients, pollution of the ground water etc. The original geologic substrate and subsequent geochemical and pedogenic regimes determine total levels of micronutrients in soils (Jiang et al., 2009). Micronutrient availability to plants can be measured in direct uptake experiments, or estimated with techniques that correlate quantities of micronutrients extracted chemically from soils (Kabata-Pendias, 2001). The minerals present in the pedosphere or lithosphere determines the rate of replenishment of micronutrients which takes place in the soil. The study of micronutrients in respect soil horizons will enable land users to determine its leaching rate, horizons with higher concentration and land-use practices that are suitable for an area. Dar, (2004) reported that there is need for monitoring the micronutrient status through analysis of soils and plant tissues in fields.

However, understanding the variations of soil profile characteristics as it relates to micronutrient status is essential for pedosphere sustainability and proper nutrient balance as required by plants. Also, information on the profile distribution of micronutrient will facilitate decisions on method/rate of fertilizer application and guide to other soil management practices which will enhance the entire ecosystem. The aim of this study is to determine horizon differences in micronutrients (Fe, Mn, Cu, and Zn) content of soils underlain by coastal plain sand.

Materials and Methods

Study Area

The study was carried out in Egbema in Owerri agricultural zone of Imo State, South-east Nigeria, located between Latitudes 5° 33' N and 5° 58' N and longitude 6° 50' E and 6° 59' E. It has a humid tropical climate with an average annual rainfall ranging between 1750 mm and 2500 mm, annual temperature ranging between 24 °C and 31°C and high relative humidity (above 80 %) during the rainy season (NIMET, 2015). Soils of the area are derived from Coastal Plain Sand (Benin Formation) and Alluvium deposit. The original vegetation of the Egbema was tropical rainforest (FDALR, 1985). The rainforest has however been destroyed adversely through anthropogenic activities and replaced largely with oil palm bush.

Soil Sampling and Laboratory Analysis

A previous study of the sites was conducted in the early 2015; and this was followed by field sampling. Two sites (location) were randomly selected from 4 major locations that made up the sampling area. One profile pit was dug in each location. The study sites and profile pits were geo-referenced with the aid of a hand held Global Positioning System (GPS) receiver. The profile pits were described using FAO, (2006) guidelines. Delineation of horizon boundaries was accomplished before actual sample collection for laboratory analyses and samples were collected according to horizons. Ten bulked soil samples (5 per pedon) collected were air-dried, gently crushed and passed through 2 mm sieve to obtain fine earth separates. The processed soil samples were analyzed for soil physic-chemical properties as follows particle size distribution by hydrometer method, moisture content by gravimetric method, bulk density by core method, pH (H₂O) by glass electrode pH meter in a soil water

ratio 1:2.5, organic carbon by wet digestion method, total nitrogen by micro Kjeldal method, available phosphorus by Bray II method, exchangeable bases were extracted with ammonium acetate as calcium and magnesium were determined by ethylene diamineacetic acid titration method while potassium and sodium were estimated by flame photometer, exchangeable acidity by leaching the soil with 1N KCl and titrating with 0.05N NaOH (Soil Survey Staff, 2010). The trace elements (Zn, Mn, Fe, Cu) contents of the soils were extracted as supernatant using dithionite-citrate bicarbonate Onyeonwu (2000) and Atomic Absorption Spectrophotometer (AAS) (Buck Scientific model 210 VGP USA) was used to determine the amount of the individual trace element in soil solution.

Data Analysis

The variability of soil properties within the horizons of the profiles was measured by estimating coefficient of variation (CV). The coefficient of variation was ranked according to the procedure of Wilding (1985) where $CV < 15\%$ = low variation, $CV > 15 < 35\%$ = moderate variation, $CV > 35\%$ = high variation. Correlation analysis was conducted to detect the functional relationships among soil variables.

Results and Discussion

Physical and Chemical properties of soil

The results of the physical properties showed sand particle size recorded mean of 361.6 g kg^{-1} in pedon 2 and 797.6 g kg^{-1} in pedon 1. The distribution of sand down the profile showed low variation ($CV < 15\%$) (Table 1) revealing horizons are homogeneity. In pedon 1, the AB horizon recorded the highest level of sand particle size which indicated irregular distribution of sand down the profile. The average clay content ranged from 173.6 g kg^{-1} to 473.6 g kg^{-1} . The highest quantity of clay was recorded at the argillic horizon (Bt_1) of pedon 2. However, the Bt_1 (illuvial horizon) of the two pedons contained more clay compared to the surface horizons of the pedons. This agreed with findings of (Udoh *et al.*, 2008; Chikezie *et al.*, 2009) that illuviation of clay particles increases its amount at the subsurface horizons. This is as a result of lessivage which is encouraged by intense rainfall, that promotes leaching of silicate down the profile pits and enrich the surface horizon with Fe and Al oxides which supports the formation of kaolinitic clay type.

Silt/clay ratios ranged from 0.04 - 0.45 in pedon 1 and 0.29 - 0.59 in pedon 2. Silt/clay ratio is an important criterion used in the classification of tropical soil. It is also used in the evaluation of clay migration, stage of weathering and age of parent material and soils (Nwaka, 1990; Yakubu and Ojanuga, 2013). The more highly weathered a soil is, the lower the silt fraction. Therefore, soils with silt/clay ratio of less than 0.15 are regarded as highly weathered soils (Van Wambeke, 1962). The result shows that the studied pedons have silt/clay ratio above 0.15 which indicates that the soils are relatively young with high degree of weathering potential. Such soil may lack adsorptive capacity for basic plant nutrients and may be susceptible to erosion menace.

Bulk density values ranged from $1.02 - 1.59 \text{ g cm}^{-3}$ in pedon 1 and $0.98 - 1.45 \text{ g cm}^{-3}$ in pedon 2, respectively. The results of the coefficient of variation showed moderate variation (16.7 %) in pedon 1 and low variation (13.7 %) in pedon 2. The rate of variations in the bulk density values of the different horizons of the pedons could be attributed to intense rainfall, clay migration and other pedogenic processes.

Table 1: Soil physical properties of the studied locations.

Horizon	Sand (g kg ⁻¹)	Silt (g kg ⁻¹)	Clay (g kg ⁻¹)	Silt/Clay	TC	BD (g cm ⁻³)	TP (%)	MC (%)
Pedon 1								
A	849.6	32.8	117.6	0.28	LS	1.02	60.2	56.3
AB	869.6	32.8	97.6	0.34	LS	1.21	52.7	62.8
Bt1	669.6	12.8	317.6	0.04	SCL	1.38	46.1	70.3
Bt2	829.6	52.8	117.6	0.45	SL	1.46	42.9	82.2
Bt3	769.6	12.8	217.6	0.058	SCL	1.59	37.9	95.6
Mean	797.6	28.8	173.6	0.234		1.33	48.0	73.4
CV	10.1	58.1	53.7	76.8		16.7	18.1	21.4
Pedon 2								
AP	429.6	212.8	357.6	0.59	CL	0.98	61.7	56.8
AB	429.6	132.8	437.6	0.37	C	1.26	50.7	92.2
Bt ₁	289.6	152.8	557.6	0.27	C	1.29	49.6	104.5
Bt2	329.6	152.8	517.6	0.29	C	1.33	48.1	126.2
Bt3	329.6	172.8	497.6	0.34	C	1.45	43	143.1
Mean	361.6	164.8	473.6	0.37		1.26	50.6	104.6
CV	17.8	18.4	16.5	34.4		13.7	13.6	31.7

TC= textural class, LS= loamy sand, SL= sandy loam, SCL= sandy clay loam, CL= clayey loam, C= clay, BD= bulk density, TP= total porosity, MC= moisture content, CV = coefficient of variation, <15 % = low variability, 15 ≤ 35 % = moderate variability, >35 % = high variability

Soil pH ranged between strongly acidic (5.06 - 5.35) in pedon 1 and strongly-moderately acidic (5.14 - 5.98) in pedon 2. However, the argillic horizons of pedon 2 were less acidic (moderately acidic) compared to other horizons of the two pedons. The acidic nature of the pedons is in line with the findings of (Onweremadu *et al.*, 2011; Ahukaemere *et al.*, 2016) that soils underlain by coastal plain sand are mostly acidic. Soil organic carbon ranged from 1.29 – 5.39 g kg⁻¹ in pedon 1 and 1.42 – 8.58 g kg⁻¹ in pedon 2. The organic carbon level of the studied site was low according to the rating of Esu, (1991) on soils of southern Nigeria. The highest level of organic carbon (5.39 g kg⁻¹) was recorded in the

surface horizon (A) while the least value was recorded in the Bt₃ horizon contained in pedon 1. However, the AB horizon of pedon 2 had the highest amount of organic carbon compared to other horizons of the pedons. High coefficient of variation was recorded in both pedons. This could be a reflection of organic matter deposit, rate of mineralization, residue removal and soil forming processes taking place in the soil. Several authors (Ahukaemere *et al.*, 2016; Osujieke *et al.*, 2016) have made similar findings on soils of southeastern Nigeria.

Manganese (Mn)

The result (Table 2) indicated that with the exception of the Ap horizon in pedon 2, the manganese contents of the horizons of both pedons were below the critical level (1 – 4 mg kg⁻¹) reported by (Sims and Johnson, 1991; Esu, 1991). Available Mn ranged from 0.02 – 0.35 mg kg⁻¹ in pedon 1 and 0.13 – 1.09 mg kg⁻¹ in pedon 2, respectively. The values obtained were lower than the range 3.12 – 5.88 mg kg⁻¹ reported by Verma *et al.* (2005) of Mn in alluvial plain and the range 5.96 – 13.74 mg kg⁻¹ reported by Mulima *et al.* (2015) for soils of Geidan northeast, Nigeria. The available Mn showed high variation (CV = 98.9 %, 57.6 %) in the pedons investigated. The Ap horizon of pedon 2 with the least organic carbon content had the highest value of Mn (1.09 mg kg⁻¹). However, Rengel, (2007) reported that organic residue effects the immediate and potential availability of manganese in soil. Available Mn contents of the pedons did not follow specific trend of decrease down the profile. This is contrary to findings of Sangwan and Singh (1993) that reported irregular pattern of increase in available Mn content with soil depth.

Zinc (Zn)

The available zinc (Zn) varied from 0.20 – 0.77 mg kg⁻¹ with mean value of 0.37 mg kg⁻¹ in pedon 1 and 0.22 – 0.96 mg kg⁻¹ with mean value of 0.66 mg kg⁻¹ in pedon 2 (Table 2). The result also indicated that with exception of Bt₂ horizon (0.77 mg kg⁻¹), all the other horizons in pedon 1 were found in deficient range by considering 0.6 mg kg⁻¹ as the critical limit of zinc suggested by Lindsay and Norvel (1978). Also, only Bt₂ and Bt₃ horizon in pedon 2 were found in deficient range with values (0.22 mg kg⁻¹, 0.51 mg kg⁻¹) lower than the critical limit. Available Zn had no specific trend of increase and decrease with soil depth in pedon 1 and pedon 2, respectively. However, as Zn decreases with depths, its implication here is that plants may not have a Zn “store” in the lower surface. This is in line with the findings of Mustapha *et al.* (2011) in soils of Gombe, Nigeria. Zinc also recorded high coefficient of variation (65.5 %, 44.71 %) in both pedons. The high variation of available Zn between and among the horizons of both pedons agreed with the findings of Jobbage and Jackson, (2001) that leaching could transport micronutrient from one soil horizon to another. The studied soils show that pedon 2 has more level of available Zn over pedon 1 which could be as a result of soil pH and texture. Hence, coarse textured soils are more likely to be Zn deficient than fine textured soils while decrease in soil pH reduces Zn availability.

Iron (Fe)

Available Fe ranged from 36.6 – 108 mg kg⁻¹ and 19 – 50.6 mg kg⁻¹ in pedons 1 and 2, respectively. The iron content of the two pedons as shown in Table 2 were above the critical levels of 2.5 – 5.8 mg kg⁻¹ (Deb and Sakal, 2002) and > 4.5 mg kg⁻¹ (Kparmwang *et al.*, 2000). None of the horizons were found in deficient range by considering these critical limits. Fe distributed irregularly down the pit in all the pedons. The highest level of available Fe content was recorded at the Bt₁ horizon of pedon 1 and Bt₂ horizon of pedon 2, respectively.

Table 2: Soil chemical properties of the studied locations.

Horizon	pH (H ₂ O)	OC → g/kg ←	TN ←	Av. P (mg/kg)	Ca	Mg	K → cmol/kg ←	Na	Al	H	ECEC	Mn → mg/kg ←	Fe	Cu	Zn
Pedon 1															
A	5.21	5.39	0.58	13.51	2.67	2.2	0.011	0.002	1.36	0.40	6.643	0.35	47.3	0.091	0.205
AB	5.54	5.19	0.55	13.37	0.18	0.4	0.019	0.007	0.00	0.48	1.086	0.05	48.0	0.256	0.435
Bt ₁	5.06	2.39	0.25	7.20	4.67	2.9	0.015	0.002	2.64	0.56	10.787	0.10	36.6	0.099	0.204
Bt ₂	5.35	1.39	0.15	6.44	2.50	1.8	0.015	0.004	0.00	0.48	4.799	0.02	108.0	0.142	0.774
Bt ₃	5.14	1.29	0.19	4.34	1.83	1.7	0.011	0.009	1.92	0.24	5.710	0.02	55.1	0.164	0.244
Mean	5.26	3.13	0.34	8.97	2.37	1.80	0.01	0.01	1.18	0.43	5.81	0.11	59.00	0.150	0.37
CV (%)	3.60	64.50	59.60	46.90	68.30	50.8	23.60	64.90	99.0	28.1	60.18	98.9	47.80	44.10	65.5
Pedon 2															
A _p	5.20	1.42	1.47	2.17	2.83	4.0	0.017	0.003	8.84	1.32	17.010	1.09	24.5	0.524	0.768
AB	5.33	8.58	0.89	2.38	4.67	3.4	0.022	0.033	10.04	0.40	18.565	0.43	44.0	0.546	0.962
Bt ₁	5.81	3.19	0.33	5.53	3.33	3.2	0.012	0.002	10.96	1.80	19.304	0.76	31.0	0.613	0.825
Bt ₂	5.14	2.39	0.20	2.52	5.50	2.6	0.016	0.002	10.36	2.57	21.048	0.13	19.0	0.143	0.220
Bt ₃	5.98	2.99	0.31	4.69	0.08	4.2	0.016	0.063	12.80	1.50	18.659	0.83	50.6	0.539	0.512
Mean	5.49	3.71	0.64	3.46	3.28	3.48	0.02	0.02	10.60	1.52	18.92	0.65	33.8	0.473	0.66
CV (%)	6.92	75.53	83.81	44.60	63.4	18.4	21.6	91.9	13.7	51.8	7.71	57.60	39.10	39.71	44.71

OC = Organic carbon, TN = Total nitrogen, Ca = Calcium, Mg = Magnesium, K = potassium, Na = Sodium, Al = Aluminum, H = Hydrogen,
ECEC = Effective cation exchange capacity, Mn = Manganese, Fe = Iron, Cu = copper, Zn = Zinc

The amount of available Fe in these soils could be due to the acid conditions of the soils resulting from leaching of most basic cation due to intense rainfall. Available Fe poses no fertility problem in the soils studied. However, Biwe, (2012) reported that the presence of Fe in high concentration in soils could lead to its precipitation and accumulation and upon complex chemical reactions lead to the formation of laterite. This could further lead to restriction of root penetration due to indurations formed as a result of alternate drying and wetting of the soils.

Table 3: Relationship between micronutrient contents with soil physicochemical properties.

Soil properties	Cu	Fe	Mn	Zn
Al	0.73**	-0.58	0.74**	0.31
Av.P	-0.32	0.28	-0.45	-0.24
BD	-0.47	0.51	-0.57	-0.43
Ca	-0.16	-0.37	-0.12	0.00
Clay	0.58**	-0.64	0.59	0.16
ECEC	0.59*	-0.61	0.65	0.26
H	0.24	-0.56	0.41	-0.09
K	0.24	-0.09	0.08	0.37
MC	0.19	-0.09	0.13	-0.15
Mg	0.64	-0.39	0.81	0.35
Na	0.48	0.08	0.36	0.17
OC	0.40	-0.14	0.00	0.43
pH(H ₂ O)	0.65	0.09	0.47	0.37
Sand	-0.67**	0.63	-0.72	-0.27
TN	0.55	-0.37	0.64*	0.52
TP	0.46	-0.59	0.56	0.42

*and** = significant at 0.05 and 0.01 probability levels, respectively. OC = Organic carbon, TN = Total nitrogen, Ca = Calcium, Mg = Magnesium, K = potassium, Na = Sodium, Al = Aluminum, H = Hydrogen, ECEC = Effective cation exchange capacity, Mn = Manganese, Fe = Iron, Cu = copper, Zn = Zinc,

Copper (Cu)

The available copper (Cu) varied from 0.10 - 0.3 mg kg⁻¹ with mean value of 0.15 mg kg⁻¹ in pedon 1 and 0.1 – 0.6 mg kg⁻¹ with mean value of 0.47 mg kg⁻¹ in pedon 2 (Table 2). In pedon 1, with exception of AB horizon (0.25 mg kg⁻¹), all the other horizons were found in deficient range by considering 0.20 mg kg⁻¹ as the critical limit of Cu suggested by (Lindsay and Norvel, 1978; Rhue and Kidder, 1983). Also, in pedon 2, only Bt₂ horizon was found in deficient range with value (0.14 mg kg⁻¹) lower than the critical limit. The available Cu recorded were below the range (1 – 3 mg kg⁻¹) reported by Deb and Sakal, (2002) as the critical level while, Tisdale *et al.* (2003) recommended critical value of 1.0 – 2.0 mg kg⁻¹ for Cu. Hence, Cu availability in the surface horizon falls below the critical limit, it is imperative to supplement it for sustainable crop production. This is in concurrence with the findings of Mustapha *et al.* (2011) in soils of Akko in northeast Nigeria. The distribution of copper increased down the profile in irregular pattern with the highest concentration in AB horizon in pedon 1 and Bt₁ horizon in pedon 2. Copper availability showed high variation (39.7 %, 44.1 %) in both pedons. The variation agreed with the works of Jiang *et al.* (2006) which attributed it to anthropogenic disturbance, leaching and topsoil accumulation of nutrients.

Interaction between Soil Properties and Micronutrients

The correlation between the soil micronutrients and some soil physico-chemical properties are presented in Table 3. Though not significant, soil bulk density correlated negatively ($r = -0.47$, $r = -0.57$, $r = -0.43$) with Cu, Mn and Zn. Non significant but positive correlation ($r = 0.28$) was observed between bulk density and Fe. Clay had significant positive correlation ($r = 0.58$, $p = 0.05$) with Cu, negative correlation ($r = -0.64$) with Fe and positive correlation ($r = 0.59$, $r = 0.16$) with Mn and Zn (Table 3). The significant relationship between clay and Cu conformed to the findings of (Sadiq *et al.*, 2008; Oyinlola and Chude, 2010) that clay is of significant important in the availability of Cu. Organic carbon had positive correlation ($r = 0.40$, $r = 0.43$) with Cu and Zn but correlated negatively ($r = -0.14$) with Fe and correlated neutrally (0.00) with Mn. The soil pH(H₂O) correlated positively but non-significantly ($r = 0.65$, $r = 0.09$, $r = 0.47$, $r = 0.37$) with Cu, Fe, Mn and Zn. The relationship indicates that pH did not significantly influence their availability in the soils. This is in conformity with the findings of Kparmwang *et al.* (2000) in the sedimentary soils. Sims and Johnson (1991) reported that the availability of trace element in the soil is affected by pH and texture. Also, these results obtained from the study conformed to the report of Debs and Sakal (2002) and Tisdale *et al.*, (2003) that the availability of most micronutrients in soils depend on soil pH, OC content and adsorptive surfaces. However, the positive correlation implies that increase in one soil property increases the other while, negative correlation implies that increase in one soil property decreases the other and vice versa.

Conclusion

The results of the study revealed that the soils were generally acidic, low in exchangeable cations, organic carbon and total nitrogen contents. Generally, micronutrient values with the exception of Fe recorded in the study were below critical levels. The relationship between soil properties and micronutrients showed the relevance and impact of these soil properties on the availability of micronutrients. For sustainable soil optimum productivity, micronutrient fertilizers (copper, manganese and zinc) and organic matter

application should be applied by farmers within and around the environment of the study area for quality and profitable crop production.

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Fertility of Soils over Loess in the Danubian Plain

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Abstract

The loess in the Danubian plain is rich of nutrients and there is situated the south border of so called “corn belt of Europe”, where are the most fertile soils of Balkan Peninsula. There are five main typical soil types spread over loess - Chernozems, Phaeozems, Kastanozems, Regosols and Calcisols. There is also a big diversity in the content of basic nutrient elements – it varies between low and high content of organic carbon and mobile forms of nitrogen, phosphorous and potassium. As a whole there is shortage of phosphorus in all soil types. Soils over loess are characterized by a surface layer that is rich in organic matter, minerals and nutrients with abundant natural grass vegetation and high fertility soil types such as Chernozems, Phaeozems and Kastanozems. Eroded and shallow soils such as Regosols and Calcisols have low quantities of major nutrient elements as mobile nitrogen, phosphorus, and total organic matter, consequently their fertility is low.

Key words: Agrochemical properties, soil fertility, Chernozems, Phaeozems, Kastanozems, Regosols, Calcisols

Introduction

Soils over loess are among the most fertile in the world. Loess is full of minerals and drains water very well, it is easily tilled, or broken up for planting seeds. Under appropriate climatic conditions, this is some of the most agriculturally productive land in the world. The fine grains weather rapidly due to their large surface area, making soils derived from loess rich of nutrients. Loess deposits are widely distributed on a global basis, covering approximately 10% of the total land cover (Rhotonet at., 2017).

Since Roman Empire in Danubian plain many villages and towns were created and settlers had been produced good yields for over two thousand years. According to Catt (2001) soil fertility depends on a range of physical and chemical properties that are determined by present climatic and biological factors, past climatic and geomorphological history and recent human activities as well as by the nature of the soil parent material. One theory states that the fertility of loess soils is due to cation exchange capacity (the ability of plants to absorb nutrients from the soil) and porosity (the air-filled space in the soil).

The research of the agrochemical properties and characteristics of the soils over loess on soft rocks such as Chernozems, Phaeozems, Kastanozems, Regosols and Calcisols were made to clarify their agrochemical conditions (Koinov et al., 1998; Krasteva et al., 2011; Lubenova et al., 2011, Hristov, 2013; Teoharov et al., 2015, Ilinkin et al., 2017, Bogadanov,

et al. 2017). Some key features of these soils have been studied. There is a big diversity in the content of basic nutrient elements – it varies between low and nearly medium content of total carbon and mobile forms of phosphorous, nitrogen and potassium. The pH varies from slight acid to slight alkaline and it is favorable for many crops.

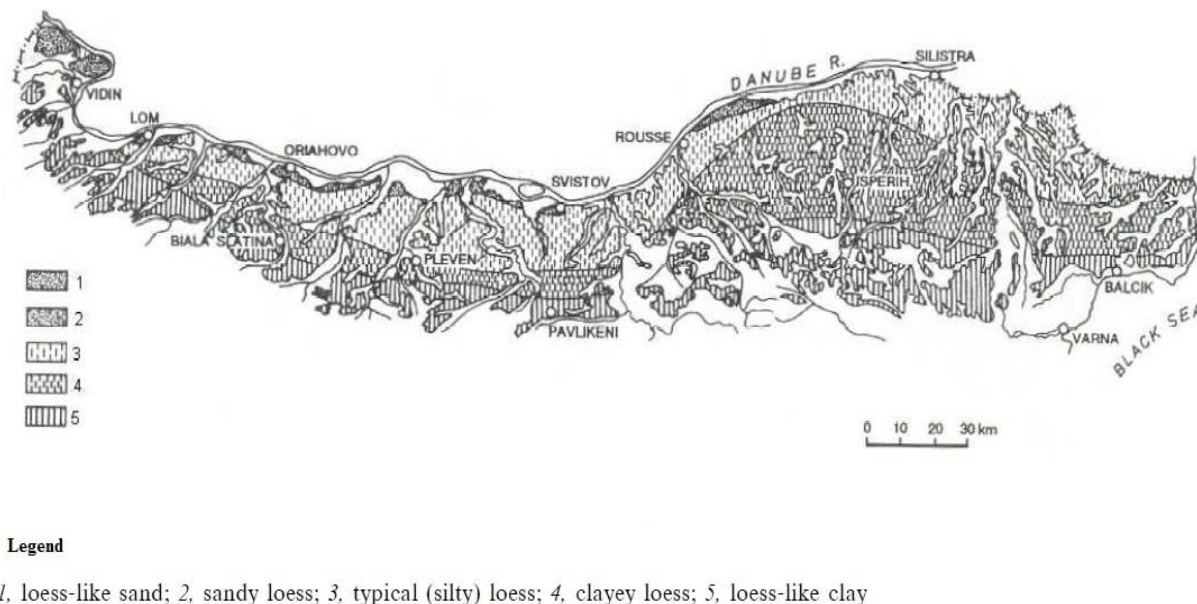


Figure 1. *The Loess lithofacial varieties in Danubian plain (Minkov and Stoilov, 1965; digitized by Evlogiev and Evstatiev, 2007)*

The loess in Danubian plain constitutes the northern part of Bulgaria, situated north of the Balkan Mountains and south of the Danube River (figure 1). Its western border is the Timok River and to the east it borders the Black Sea. The relief of the Danubian plain is hilly, featuring numerous plateaus and river valleys and the most fertile soils in Bulgaria. The climate is markedly temperate continental with a weak Black Sea influence in the east. Precipitation is on average 450–650 mm a year (Galabov, 1982). Loess is well sorted, usually calcareous, non-stratified, yellowish-grey, aeolianclastic sediment. Loess is mostly created by wind, but can also be formed by glaciers. When glaciers grind rocks to a fine powder, loess can form. Streams carry the powder to the end of the glacier. This sediment becomes loess. It consists predominantly of silt-sized particles, and contains normally less than 20 percent clay and less than 15 percent sand.

The aim of the study is to clarify their agrochemical properties and characteristics which provides information about their fertility. Along with the well-developed deep soils such as Chernozems (CH), Kastanozems (KS) and Phaeozems (PH) and other zonal soils in Northern Bulgaria (figure 2), there are soils with weak developed profile, classified as Regosols (RG) and Calcisols (CL). Understanding the impact of the natural development of plant cover on the processes of humus formation and mineralization of soil organic matter will help to improve the fertility of such soil types.

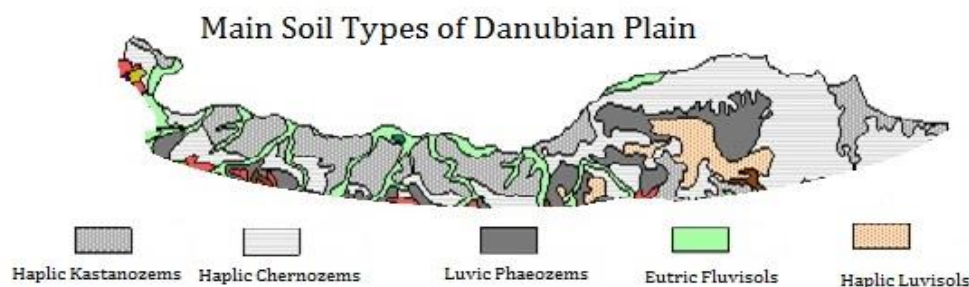


Figure 2. Main soil types of Danubian plain (Soil map of Bulgaria M 1:1,000,000, Kolchakov, 1994),

Materials and Methods

According to soil geographic zoning, the studied sites and soils fall into the Danubian plain, Danubian subzone province of Chernozems and hills of Grey forest soils (Koinov et al., 1972, 1998; Gyurov et al., 2001). The whole area includes the studied sites, which are the lands of the settlements - Yakimovo, Kovachitsa and Stanevo, Montana district; Muselievo and Milkovitsa, Pleven region; Trustenik and Mechka, Rousse Region. The region covers the northern parts of the Danube Plain from Archar River (to the west) to the Roussenski Lom River (to the east). The data of the soil profiles 29, 30, 31 are taken from “Atlas of the soils in Bulgaria” (Koinov et al., 1998). Studied soils are uncultivated.



Photo 1. The loess in the Danubian plain, Bulgaria

For the determination of organic matter of the soils was used method of Tyurin (Belchikova, 1965); ammonia and nitrate nitrogen by Bremner and Keeney (1966); the mobile forms of phosphorus and potassium in the acetate-lactate method of Ivanov (1984) and pH in water with combined “pH and EC meter”, Microsoft Excel (2010) is used for graph and statistics.

Results and Discussion

The soil reaction is essential for internal soil processes and the level of soil fertility. Soil acidity depends on the type of soil, parent rock, vegetation and it can vary widely. Loess in the Danubian valley is usually with alkaline reaction.

Table 1. Agrochemical properties of the soils over loess in the Danubian plain

Number (Soil Sample)	Soil Profile number	Depth cm	Soil Type* WRB2006	Horizon	pH (H ₂ O)	$\Sigma \text{NH}_4^+ + \text{NO}_3^-$ mg/kg	P ₂ O ₅ mg/100 g	K ₂ O mg/100 g	Organic Mater (humus)%
1	1	0 - 13	KS	A _{k1}	7.5	25.4	5.7	48.0	4.13
2	1	13 - 26	KS	AC _{k1}	7.5	12.0	3.2	20.0	1.54
3	1	26 - 41	KS	C _{k1}	7.4	7.9	3.2	18.9	1.02
4	6	0 - 22	CH	A ₁	7.4	10.8	4.5	44.5	1.62
5	6	22 - 47	CH	A _{k2}	7.5	16.5	1.2	18.0	1.39
6	6	47 - 74	CH	A _{k3}	7.6	15.1	2.0	18.8	1.14
7	6	74 - 104	CH	AC _{k1}	7.6	11.1	1.4	18.8	1.14
8	6	104 - 145	CH	C _{k1}	7.7	12.1	4.1	16.5	0.76
9	7	0 - 20	CH	A _{k1}	7.5	20.5	6.3	37.5	4.48
10	7	20 - 42	CH	A _{k2}	7.4	22.2	4.1	21.5	3.03
11	7	42 - 65	CH	A _{k3}	7.6	10.4	2.8	17.5	1.79
12	7	65 - 90	CH	AC _{k1}	7.7	14.6	2.5	16.5	1.26
13	7	90 - 110	CH	C _{k1}	7.1	13.5	2.0	16.7	0.83
14	7	110 - 130	CH	C _{k2}	7.7	10.8	2.5	15.5	0.66
15	8	0 - 21	KS	A _{k1}	7.2	15.1	4.0	14.5	2.59
16	8	21 - 36	KS	AC _{k1}	7.2	10.4	2.9	12.0	1.83
17	8	36 - 45	KS	C _{k1}	7.3	8.7	2.9	13.0	1.05
18	9	0 - 20	KS	A _{k1}	7.3	15.5	4.2	14.0	2.60
19	9	20 - 40	KS	C _{k1}	7.5	13.1	4.0	13.5	1.15
20	9	40 - 60	KS	C _{k2}	7.5	12.4	3.4	13.5	0.91
21	10	0 - 22	RG	A _{k1}	7.2	17.4	3.5	18.0	2.30
22	10	22 - 33	RG	AC _{k1}	7.3	13.5	3.6	13.0	0.91
23	10	33 - 50	RG	C _{k1}	7.4	11.4	3.2	9.0	0.30
24	11	0 - 18	CL	A _{k1}	7.4	15.2	3.5	12.5	2.23
25	11	18 - 35	CL	C _{k1}	7.7	10.8	2.9	13.5	0.41
26	12	0 - 10	CL	A _{k1}	7.5	16.8	4.2	16.5	2.62
27	12	10 - 32	CL	C _{k1}	7.6	7.1	3.5	9.0	0.74
28	14	0 - 16	RG	A _{k1}	7.9	16.0	2.0	17.2	1.83
29	14	16 - 32	RG	AC _{k1}	7.5	13.4	2.3	24.5	1.35
30	14	32 - 50	RG	C _{k1}	7.7	5.9	2.4	17.8	0.61
31	15	0 - 16	RG	A _{k1}	7.2	16.0	2.3	24.5	2.21
32	15	16 - 35	RG	C _{k1}	7.5	11.2	2.5	15.5	0.71
33	16	0 - 15	RG	A _{k1}	7.7	14.6	2.4	17.8	1.81
34	16	15 - 30	RG	C _{k1}	7.8	9.3	2.4	10.0	0.32
35	17	0 - 21	RG	A _{k1}	7.7	14.9	3.4	18.8	2.68
36	17	21 - 40	RG	C _{k1}	7.8	9.7	2.6	12.5	1.14
37	17	40 - 55	RG	C _{k2}	8.0	10.1	2.9	12.5	0.64
38	18	0 - 14	RG	A _{k1}	7.7	9.3	4.0	33.5	1.78
39	18	14 - 30	RG	C _{k1}	8.0	9.7	2.9	18.0	0.29
40	19	0 - 15	CL	A _{k1}	7.7	12.3	2.6	44.5	2.16
41	19	15 - 30	CL	C _{k1}	8.0	8.6	3.4	14.5	0.76

*Soil Types - CH = Chernozems; KS = Kastanozems; RG= Regosols; CL=Calcisols

Table 1. Agrochemical properties of the soils over loess in the Danubian plain (continue)

Number (Soil Sample)	Soil Profile number	Depth cm	Soil Type* WRB2006	Horizon	pH (H ₂ O)	$\Sigma \text{NH}_4^+ + \text{NO}_3^-$ mg/kg	P ₂ O ₅ mg/100 g	K ₂ O mg/100 g	Organic Mater (humus)%
42	20	0 – 11	CH	A _{k1}	7.3	12.0	4.4	18.9	2.89
43	20	11 – 25	CH	A _{k2}	7.2	10.8	2.9	17.8	1.96
44	20	25 – 57	CH	A _{k3}	7.4	7.8	2.6	21.8	1.03
45	20	57 - 84	CH	A _{k4}	7.8	8.6	4.5	21.8	0.78
46	20	84 - 120	CH	AC _{k1}	7.9	6.0	4.1	18.8	0.93
47	20	120-150	CH	C _{k1}	7.8	9.0	6.5	17.8	0.93
48	20	150 - 200	CH	C _{k2}	7.8	9.7	5.4	17.5	0.74
49	21	0 – 21	KS	A _{k1}	8.0	10.9	3.4	18.0	3.04
50	21	21 – 40	KS	AC _{k1}	7.8	7.1	2.7	12.5	1.37
51	21	40 - 60	KS	C _{k1}	8.0	6.0	3.1	10.0	0.83
52	23	0 – 25	KS	A _{k1}	7.7	12.7	3.3	23.5	3.77
53	23	25 – 45	KS	C _{k1}	8.0	9.3	1.9	10.2	1.18
54	24	0 – 19	CL	A _{k1}	7.4	12.7	3.1	16.5	2.6
55	24	19 - 38	CL	C _{k1}	7.7	10.8	2.9	10.2	0.82
56	25	0 – 20	KS	A _{k1}	7.7	15.7	9.4	29.0	3.14
57	25	20 – 40	KS	AC _{k1}	7.5	16.1	8.8	21.8	1.57
58	25	40 - 60	KS	C _{k1}	7.7	12.4	8.2	18.8	0.83
59	26	0 – 18	KS	A _{k1}	7.5	12.3	5.8	46.5	3.82
60	26	18 – 42	KS	AC _{k1}	7.8	9.7	4.9	40.0	1.47
61	26	42 - 55	KS	C _{k1}	7.7	8.6	3.7	29.0	1.47
62	27	0 - 18	PH	A ₁	6.1	10.9	3.8	31.0	3.43
63	27	18 – 40	PH	A ₂	6.2	14.1	2.8	18.8	2.35
64	27	40 – 75	PH	A ₃	6.4	10.1	3.8	18.9	1.27
65	27	75 – 108	PH	AC ₁	6.4	6.2	5.2	21.8	0.98
66	27	108 – 139	PH	C ₁	6.5	5.2	3.3	18.8	0.98
67	27	139 - 160	PH	C _{k2}	7.7	7.1	1.1	16.5	0.98
68	29	0 – 22	KS	A _{k1}	7.5	29.4	3.0	41.0	3.76
69	29	22 – 47	KS	A _{k2}	7.7	12.6	1.4	16.0	2.4
70	29	47 – 79	KS	A _{k3}	7.8	4.2	1.0	12.0	1.70
71	29	79 – 119	KS	AC _{k1}	7.9	4.2	0.8	9.0	1.3
72	29	119 - 140	KS	C _{k1}	7.9	4.2	0.7	8.0	1.2
73	30	0 - 27	CH	A _{k1}	7.0	32.9	1.5	42.0	4.7
74	30	27 – 45	CH	A _{k2}	7.0	14.7	2.3	26.1	3.38
75	30	45 - 65	CH	AC _{k1}	7.3	10.5	1.4	21.0	1.27
76	31	0 - 12	PH	A ₁	5.8	49.7	2.0	28.0	6.13
77	31	12 -35	PH	A ₂	5.2	34.3	0.9	22.0	1.56
78	31	35 - 55	PH	A ₃	5.5	14.0	1.5	29.0	1.01

*Soil Types - CH = Chernozems; KS = Kastanozems; RG= Regosols; CL=Calcisols

The pH (H₂O) in different loess types could be 9.5 but for loess sediments it is about 7.0. The reaction of the environment in loess sediments testifies to the diversity of geochemical conditions in which soil formation occurs. The main components that determine the alkaline reaction are CaCO₃ and MgCO₃. Loess of the Danubian plain contains up to 25% carbonates and their distribution in the vertical depth is unequal (Stoilov, 1984). The soil results show that pH could vary from 5.2 to 8.0 (Table 1 and Table 2) and the mean value is 7.4. The low values (about 6 pH) are typical for the highest points of our soil samples in A horizons. In these places rains wash out the carbonates and soil reaction goes down. Also in

south, far from the river Danube, where are spread Phaeozems (PH) the carbonates are washed in deep horizons (C_k), mainly by organic acids under forest. Highest values of pH are typical for Kastanozems (KS) and Calcisols (CL), because of high percent of carbonates. The well-known fact is that most fertile soils are soils with pH between 6 – 7, because in that range there are most available nutrients (Fink, 1976). These soils are mainly Chernozems (CH) and Phaeozems. Higher pH values in the C horizon in most profiles are evidence of the strong influence of the loess and its alkaline reaction.

One of the reason that soils over loess are fertile is the fact that at a soil pH range of 6 to 8, the microbial conversion of NH_4^+ to NO_3^- (nitrification process) is rapid. Most annual crops tend to take up most nitrogen as nitrate. In acidic soils (pH less than 6), microbial activity is low, the nitrification process is slower in this case NH_4^+ is more available to plants (McKenzie, 2003). The amount of “mineral” nitrogen (the sum of ammonium and nitrate) is from moderate to low – ranging between 49.7 to 4.9 mg/kg and decreases in depth of the soil profiles (Penkov, 2005). The amount of nitrate nitrogen is two to three times lower than ammonium nitrogen, which is probably related to the time of soil sampling, at the end of spring (Hristov et al., 2009). The process of nitrification then proceeds slowly as the temperatures are still lower and the soil is not sufficiently warm (Pryanishnikov, 1965). Soil pH is very important factor in nitrogen fixation by legume crops. The survival and activity of Rhizobium bacteria declines as soil acidity increases. Deep soils such as Phaeozems, Chernozems and Kastanozems have more ammonium and nitrate nitrogen than shallow soils as Regosols and Calcisols.

Available phosphorus oxide (P_2O_5) and potassium oxide (K_2O) commonly referred to mobile phosphate, and potassium. Well known fact is that phosphorus moves little because of the low amount dissolved in the soil solution. Leaching losses of inorganic phosphorus are generally low. Research of the chemistry of soil inorganic phosphorus has shown a complex system of reactions and compound formation dependent on factors such as soil pH; type and amount of soil minerals, amount of phosphorus in the soil, and other soil factors (Diaz et al., 2011).

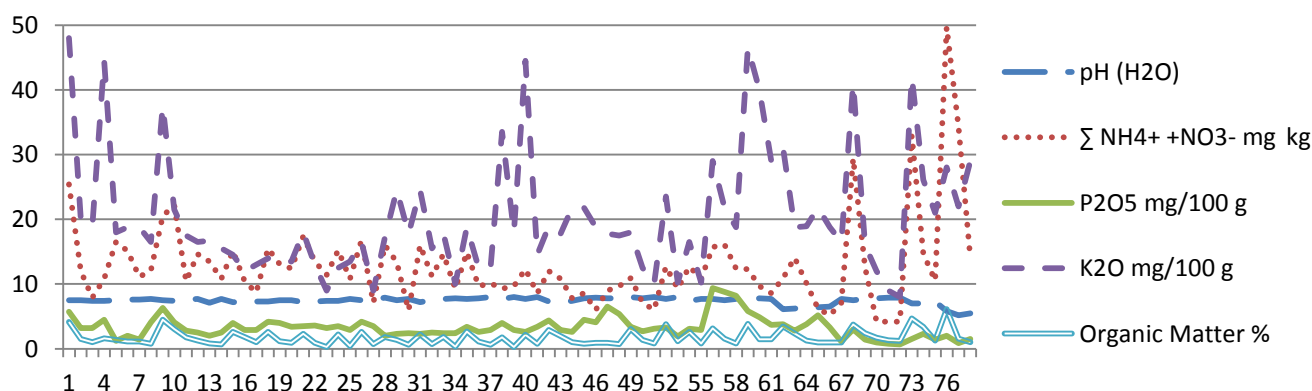


Figure 3. Agrochemical values of the soils

The amount of available phosphorus oxide (P_2O_5) in studied soils is low (Table 1, Fig. 3). The values are ranging from 0.7 to 9.40 mg/100g (Table 2), the median and mode are respectively 3.05 and 2.90. Therefore, by the amounts less than 5 mg/100g of soil, the plants

will suffer a severe shortage of this element. In soils over loess the predominant form of mineral phosphorus is associated with calcium or magnesium minerals, because the loess is rich of carbonates, that is one of the reasons for the low amount of available phosphorus oxide (P_2O_5).

Potassium is very widely distributed in studied soils as a constituent of silicate minerals such as orthoclase and microcline, and certain forms of mica, muscovite and etc. Under the influence of various weathering factors (temperature changes and the influence of water) these and other potash-containing sediments are converted slowly to clay rich of potash. In terms of the potassium's stock (K_2O), studied soils are in better condition than mineral nitrogen and available phosphorus (Valchovski et al., 2015). Its quantity varies between 8 and 48 mg/100g soil, and in Phaeozems, Kastanozem and Chernozems this quantity is significantly higher than in Calcisols and Regosols (Table 1 and 2).

Table 2. Descriptive statistic of agrochemical properties

	$pH (H_2O)$	$\sum NH_4^+ + NO_3^-$ mg/kg	P_2O_5 mg/100 g	K_2O mg/100 g	Organic Matter %
Mean	7.42	12.87	3.30	20.29	1.75
Standard Error	0.06	0.79	0.19	1.06	0.13
Median	7.50	11.30	3.05	18.00	1.36
Mode	7.70	10.80	2.90	18.80	1.14
Standard Deviation	0.56	7.01	1.67	9.40	1.15
Sample Variance	0.31	49.10	2.77	88.35	1.33
Kurtosis	4.96	10.63	3.17	1.59	2.02
Skewness	-2.14	2.74	1.43	1.43	1.38
Range	2.80	45.50	8.70	40.00	5.84
Minimum	5.20	4.20	0.70	8.00	0.29
Maximum	8.00	49.70	9.40	48.00	6.13
Count	78	78	78	78	78
Confidence Level(95.0%)	0.13	1.58	0.38	2.12	0.26

As it was mentioned the loess is rich of potash primary minerals such as micas and feldspars and secondary minerals such as illite (Koinov et al., 1998). Surface layers contain more potassium oxide (K_2O) than the subsurface horizons. In surface horizons under atmospheric influence, micaceous minerals and possibly feldspars slightly more weathered and these minerals release potassium more readily than the K-bearing minerals at the lower depths (Dubetz et al., 1981). According to Nikolova et al., (1995) in topsoil horizons Kastanozems, Chernozems and Phaeozems have very good reserves of K_2O (from 35 – 28 K_2O mg/100g soil) and Calcisols and Regosols have moderate quantity.

Generally soils over loess are characterized by a surface layer that is rich in organic matter (humus), resulting in a well-aggregated structure with abundant natural grass vegetation (Hristov et al., 2017). Content of humus varies from 6.3 to 1.0 % in the upper part of soil horizons, decreases in depth to 0.29 % (Table 1 and 2). Usually humic type of humus prevail over fulvic and the type of humus is humic or fulvic-humic (Filcheva et al, 2014).

According to Artinova (2015) classification, Regosols and Calcisols have low organic matter content (1 – 2 %) and moderate humus content (2.1 – 3 %) in A horizon. Unusually

uncultivated Chernozems, Kastanozem and Phaeozems have high (3.1% – 5 %) and very high content (over 5 %) of soil organic matter in surface horizons. The low content in Regosols and Calcisols is due to soil erosion, because typically these soils are spread over slopes and hills (Hristov et al., 2009; Hristov, 2014).

Table 3. Correlation matrix of agrochemical properties

	<i>pH</i> (H_2O)	$\sum NH_4^+ + NO_3^-$ mg/kg	P_2O_5 mg/100 g	K_2O mg/100 g	Organic Matter %
<i>pH</i> (H_2O)	1				
$\sum NH_4^+ + NO_3^-$ mg/kg	-0.47	1			
P_2O_5 mg/100 g	0.13	0.00	1		
K_2O mg/100 g	-0.21	0.42	0.29	1	
Organic Matter %	-0.28	0.69	0.14	0.58	1

Soils over loess are traditionally considered as richest soils due to their high content of soil organic matter (humus), available for crops nitrogen, phosphorus and potassium. According to correlation analysis (Table 3) there is positive correlation (**0.69**) between soil organic matter and available nitrogen ($\sum NH_4^+ + NO_3^-$). Similar situation is between organic matter and potassium oxide (K_2O) – **0.58**. The reasons for that is high organic matter content, favorable alkaline reaction, and high content of potassium rich minerals. As it was mentioned before soil reaction of the loess is good for available nitrogen and potassium, but not for available phosphorus oxide (P_2O_5) because phosphorus is bound with calcium or magnesium minerals.

Conclusion

Studied soils are characterized by a large diversity in their agrochemical properties – from a low content of available phosphorus oxide to some average and high values of mobile nitrogen, potassium oxide and organic matter content. As a whole there is shortage of phosphorus in all soil types.

Under favorable climatic conditions, loess could develop into fertile agricultural soil. Unusually uncultivated Chernozems, Kastanozem and Phaeozems have high and very high content of soil organic matter in surface horizons, and also high content of available potassium oxide. Shallow soils such as Regosols and Calcisols have low quantities of major nutrient elements as mobile nitrogen, phosphorus, potassium and total organic matter. Therefore, it is necessary to take actions for protections of such lands that would also limit the erosion and other degradations processes.

Loess alkaline reaction is also favorable for available nitrogen and potassium and the quality of soil organic matter. All these agrochemical features are beneficial for crops which grow very well over fertile soils over loess, such as Chernozems, Kastanozems and Phaeozems. Eroded and shallow soils as Regosols and Calcisols have low fertility and usually they are not cultivated.

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Statistical Assessment of Fluvisols in “Gladino” Gravel Quarry, Chelopechene, Bulgaria

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Abstract

The paper presents results of an investigation on Fluvisols. The soils are located in “Gladino” gravel quarry, Chepintsy district, Bulgaria, on an area of 1.043 km². Soil samples were taken from fifteen soil profiles at a depth of 0-100 cm. The factors of soil formation were characterized and its physicochemical properties were studied. The changes in physicochemical properties were investigated at different soil depths and the relationships between different soil characteristics were tested by correlation analysis. The results reveal that some soil characteristics, such as the content of clay, sand, organic matter, and the soil porosity have strong positive or negative correlation with the soil depth. The soil characteristics such as acidity or alkalinity of soil (pH), the content of loam, bulk density, Total Kjeldal Nitrogen (TKN), mobile phosphorus and potassium demonstrated an insignificant or weak relationship with the soil depth. There are significant correlations between the physicochemical soil properties in 28 out of 78 cases. All results are discussed in relation to soil formation processes in the studied region.

Keywords: Fluvisols, Physicochemical properties, statistical assessment, gravel quarry.

Introduction

The sustainable development and productivity of suburban green areas depend to a great extent on the soil properties. Soil characteristics determine the existence and normal functioning of ecosystems. The studies on the soil composition and properties allow suitable planned activities to ensure efficiently and environmentally use.

Fluvisols are intrazonal and occur in the riverside environment (Donov, 1993). These soils are relatively poor in nutrients, especially in tropical areas (Edelman & Van der Voorde, 1963), and are sometimes represented by completely infertile gravels and sands. They are characterized by variable physicochemical properties (Dengiz, 2010; Woźniak & Kud, 2005), but have a favourable water regime (Duchaufour, 1965; Donovan, 1993) and good bulk density indicators (Kaczmarek et al., 2015). There is a textural variation in the soil profile (Valentin, 1991). The chemical properties of these soils are directly related to their distance from the riverbed (Amossé et al., 2015). They are characterized by acid, neutral or alkaline reaction in relation to river basins. Soil organic matter (SOM) is average or low, but varies strongly

(Woźniak & Kud, 2005) and may reach up to 2% in the surface horizon (Mitkova & Mitrikeski, 2005). The nitrogen content is high or average (Yigini et al., 2013). Fluvisols may be suitable for some forest species - willows, elms, ashes (Donov, 1993), as well as for tree fruit species such as apple, plum, pear, peach (Kalala et al., 2017) and quince (Shishkov & Kolev, 2014). Favorable water, air, and soil thermal properties indicate that these soils have been used for agriculture since ancient times. The soils are characterized by a low store of nutrient elements. Low content of organic colloids and coarse texture characterize the soils as such with low Cation Exchange Capacity (CEC) 10–15 meq/100 g and low buffer properties (Shishkov & Kolev, 2014). These soils can be used for the growing of high yield cultures if fertilized properly (Donov, 1993; Kalala et al., 2017).

Fluvisols are found between Chernozems and Gray forest soils in Northern Bulgaria, along with the rivers - Danube, Lom, Ogosta, Iskar, Osam, Yantra, Rositsa and Kamchia (Teoharov et al., 2015; Hristov, 2009). In Southern Bulgaria, they are situated between Vertisols and Cinnamonic Forest soils, along with the rivers Maritsa, Tundzha, Arda, Mesta, Struma, Iskar, and Erma (Antipov-Karataev et al., 1959; Donovan, 1993) (Fig. 1). A main soil-forming factor is the nature of the alluvial deposit (Aubert & Boulaine, 1972), which differs depending on the adjacent water basin that has carried the deposits, on the location along the river, and on the distance from the water. The weather conditions are determined by the climate zone of the respective river valley, or where the hollow is located (Donov, 1993).

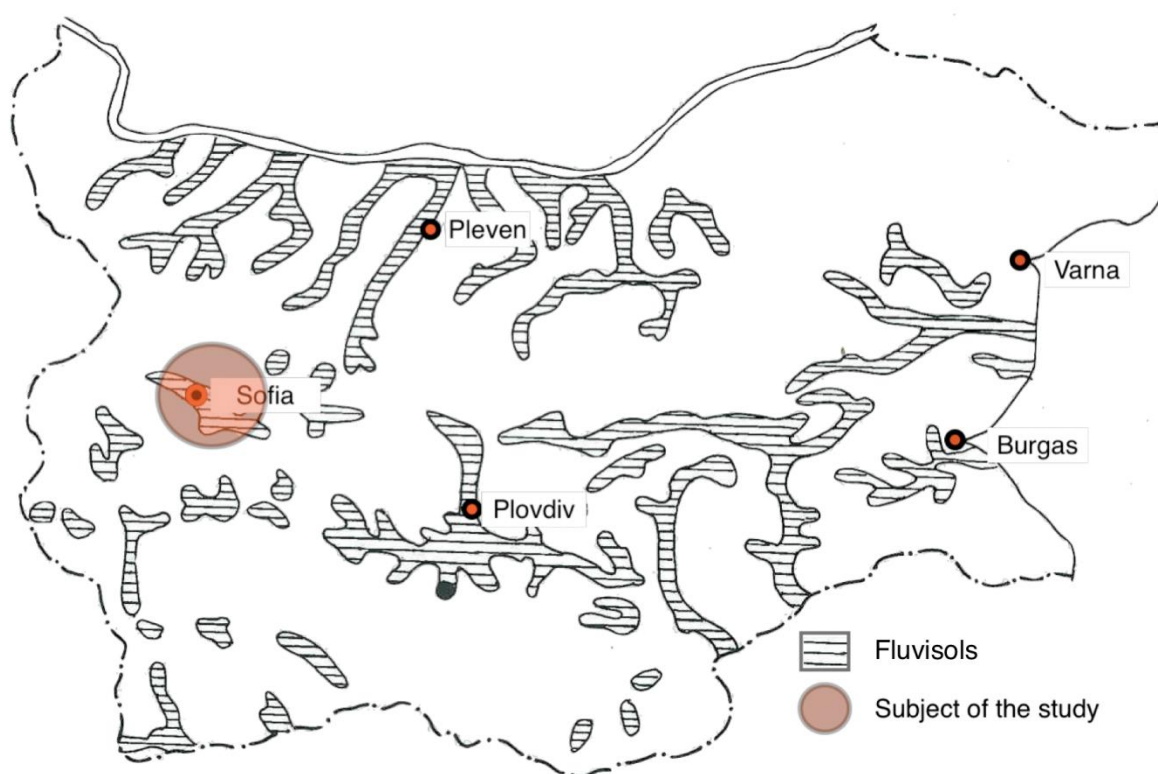


Fig. 1. Distribution of Fluvisols and subject of the study (Koynov et al., 1998)

The purpose of the study was to analyze the key properties of Fluvisols in relation to soil-forming materials and soil formation. Analyzing these processes and properties could help the effective landscape planning and increasing the productivity of suburban ecosystems.

Materials and Methods

The object

Fluvisols (WRB, 2014) occurring on the territory of “Gladino” sand and gravel quarry, located 1 km west of the village of Chelopechene, Bulgaria was the object of the study. This soil type is usually found in the Lower forest vegetation zone (0 - 600 m a. s. l.) of the Moesian forest vegetation area of Bulgaria (Zahariev et al., 1979). The studied area covers 1.043 km² (Fig.1).

Methods of study

Fifteen soil profiles at a depth of 0-100 cm were done at representative plots. A systematic sampling design was used (Petersen & Calvin, 1996). The samples were taken at depths of 0-20 cm, 20-40 cm, 40-60 cm, 60-80 cm, and 80-100 cm.

The following soil characteristic was analyzed by using the respective methods:

- Soil Organic Matter (SOM, %) by the Turin method (Donov et al., 1974);
- Total Kjeldahl Nitrogen (TKN, %) content, with a modified version of the classic Kjeldahl method (Tecator 1030);
- P₂O₅ (mg.100g⁻¹) – extraction with Ammonium Acetate and Calcium Lactate-pH 4.2 (UV-VIS spectrophotometer Perkin Elmer Lambda 5) (Ivanov, 1984);
- K₂O (mg.100g⁻¹) – extraction with Ammonium Acetate and Calcium Lactate-pH 4.2 (Flame photometer Jenway php 7) (Ivanov, 1984);
- Soil acidity (pH in water extraction and CaCl₂ extraction 1:5 w/v) – measured potentiometrically (WTW 720 pH meter);
- CaCO₃ (%) by Shaibler’s method (Eijkelkamp 08.53 calciummeter) (NEN-ISO 10693);
- Soil texture (Sand - 2 mm - 63 µm, %; Silt - 63 µm - 2 µm, %; Clay < 2 µm, %), using the sedimentation method (ISO 11277);
- Bulk density (BD, g.cm⁻³), according to the Kachinsky method (Donov et al., 1974, Cools & De Vos, 2016, DIN ISO 11272:1998, 2001);
- Total porosity (TP, %) by calculation of bulk density and relative density (Donov et al., 1974);
- Plant available water capacity (PAWC, mm), by a laboratory method, with the calculation of field capacity and permanent wilting point (Donov et al., 1974);

Data analysis

Descriptive statistics were applied using Numbers and Excel in Mac and PC, respectively. Percentage data were arcsine-square root transformed before the analysis (Compton, 1994). The relationships among the soil characteristics studied were tested by using Pearson's product-moment correlation. Pairwise correlation coefficients were calculated by using SPSS for Windows, version 16.0. Their statistical significance (the significant difference from zero) was tested at $\alpha=0.05$. Linear regression analysis was applied for additional testing for a functional relationship between the soil depth and the other characteristics. Corrected variants of regression coefficients (R^2) were calculated and the statistical significance of the relationship was tested at $\alpha=0.05$.

Results and Discussion

Soil characteristics

Soil physical parameters change slightly in the soil depth. The soil texture at a depth of 0-20 cm is almost equally distributed as sandy clay loam. At a depth of 20-40, 40-60, 60-80 cm it falls into the sandy loam texture group. The samples taken at a depth of 80-100 cm fall mainly into the loam sand group (Fig. 2). The soil texture variability is consistent with a study carried out by Singh et al. (2000).

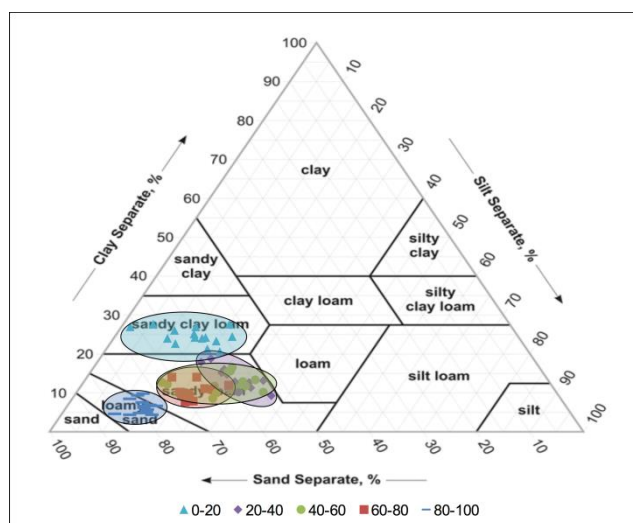


Fig. 2. Soil texture (according to Soil Survey Staff, 1975).

Texture variability of the studied soils is mainly due to the decrease in the content of the clay fraction and the increase in the content of the sand fraction with depth. The silt fraction decreases gradually with depth, except in the first layer at a depth of 0-20 cm, where this fraction has the lowest average value, whereas the clay fraction has the highest content percentage (Fig. 3). The variation of soil texture with depth is characterized by a negative linear relationship with high statistical significance for the clay fraction ($R^2=0.754$, $p<0.001$) and sand fraction ($R^2=0.609$, $p<0.001$). No statistically significant relationship was found between depth and silt fraction ($R^2=0.022$, $p=0.278$) (Fig. 4) (Table 1).

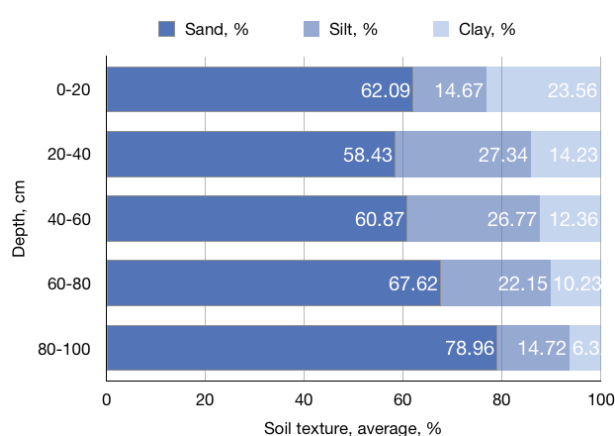
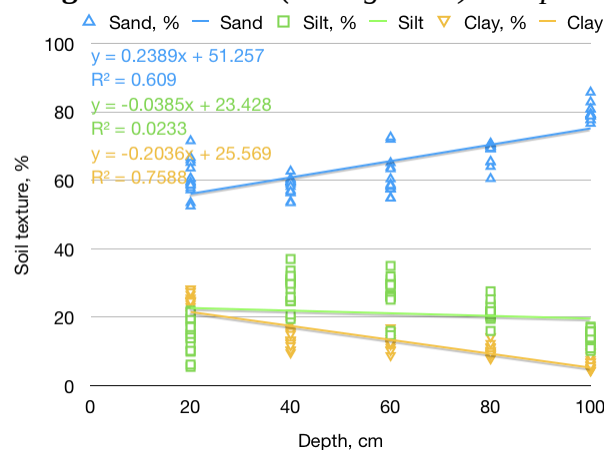
The bulk density values are between 1.23 and 1.61 g.cm⁻³ in the upper (0-20 cm) layer, varies between 1.23 and 1.61 g.cm⁻³ in the 20-40 cm layer, between 1.15 and 1.72 g.cm⁻³ in the 40-60 cm layer, between 1.02 and 1.86 g.cm⁻³ in the 60-80 cm layer and 1.12 and 1.84 g.cm⁻³ in the lower (80-100 cm) layer. Despite the weak upward trend of the maximum bulk density values with depth, there is no significant relationship between the depth and the bulk density ($R^2=0.007$, $p=0.458$).

The study of the Fluvisols showed that there is a clear downward trend in porosity with depth ($R^2=0.752$, $p<0.001$) (Fig. 5), varying from medium to low (according to Blume's classification, 1992).

Table 1. The matrix of the correlation coefficients among the soil characteristics studied.

	Sand	Silt	Clay	BD	TP	PAWC	pH (H ₂ O)	pH (CaCl ₂)	CaCO ₃	SOM	TKN	P ₂ O ₅
Silt	-0.658											
Clay	-0.635	-0.158										
BD	0.118	-0.071	-0.086									
TP	-0.549	-0.127	0.838	0.007								
PAWC	-0.008	0.092	-0.097	-0.115	-0.009							
pH (H ₂ O)	-0.118	-0.071	0.230	-0.006	0.326	0.120						
pH (CaCl ₂)	0.246	-0.272	-0.037	0.058	0.065	0.026	0.458					
CaCO ₃	-0.106	0.000	0.120	-0.011	0.069	0.044	0.080	0.100				
SOM	-0.704	0.222	0.697	-0.176	0.589	-0.065	0.166	-0.120	0.127			
TKN	-0.269	0.066	0.313	-0.020	0.282	-0.188	0.186	0.182	0.074	0.304		
P ₂ O ₅	-0.301	-0.083	0.467	-0.068	0.471	0.020	0.258	-0.032	0.117	0.249	0.323	
K ₂ O	-0.175	-0.079	0.313	0.157	0.324	-0.083	0.290	0.131	0.228	0.195	0.260	0.265

Legend: The values in Bold indicate statistically significant correlation at $p \leq 0.05$. For abbreviations of the names of soil characteristics, see part "Material and Methods"

**Fig. 3.** Soil texture (average data) in depth.**Fig. 4.** The relationship between depth and soil texture characteristics.

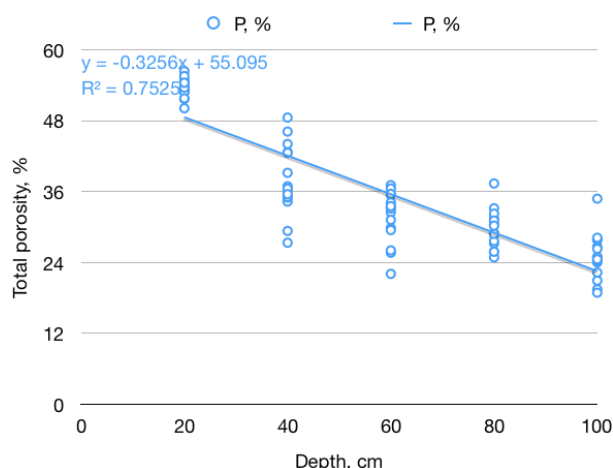


Fig. 5. The relationship between soil depth and porosity.

Pearson's product-moment correlation coefficients express the relationships among the soil characteristics (Table 1). It can be seen that roughly one-third of the correlation coefficients (28 of 78) are significantly different from zero. In other words, there are significant relationships among different soil characteristics. There are six negative correlations and all they are related to sand content. It correlates negatively with silt, clay, porosity, SOM, TKN and P_2O_5 . There is a highly significant positive correlation between the clay fraction and porosity ($r=0.838$) and a negative one between the sand fraction and porosity ($r=-0.549$), while there is no relationship between the silt fraction and porosity. Clay content correlates significantly with porosity, pH (H_2O), SOM, TKN, P_2O_5 and K_2O (positively) and with sand content (negatively). Interestingly enough, PAWC does not correlate significantly with any of the other characteristics (Table 1).

PAWC in the studied soils varies from 128.79 mm to 164.51 mm (Mean=146.03) and shows a fluctuation around the values of fresh soils (Coeff. of variation= 6.08%) (Fig. 6).

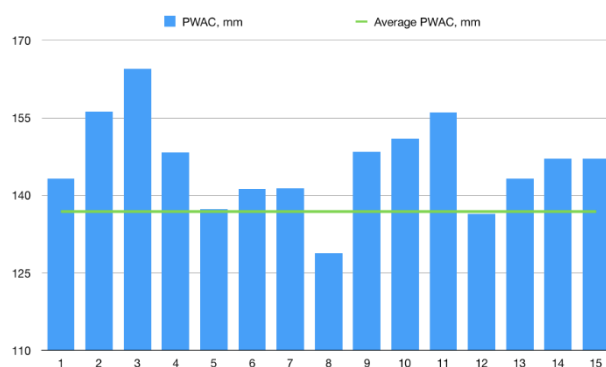


Fig. 6. PAWC variation.

The reaction of the H_2O extract of the studied soils varies from slightly acidic to slightly neutral, which is consistent with data provided by Walker et al. (2003) and Hartemink (1998) on the pH variation within the range of 5.2-7.1. The pH values in the H_2O extract are between 6.36 and 7.23 in the upper (0-20 cm) layer, pH varies between 5.88 and 7.37 in the 20-40 cm layer, between 5.74 and 6.76 in the 40-60 cm layer, between 5.76 and 7.06 in the 60-80 cm layer and between 5.76 and 7.04 the lower (80-100 cm) layer. The pH

values in the CaCl_2 extract are between 6.09 and 7.18 in the upper (0-20 cm) layer, pH varies between 5.29 and 6.82 in the 20-40 cm layer, between 5.65 and 6.53 in the 40-60 cm layer, between 5.85 and 6.85 in the 60-80 cm layer and between 6.00 and 7.1 in the lower (80-100 cm) layer. This indicates that the exchangeable acidity, which is an indicator for degradation processes, is small (Ignatova & Damyanova, 2010). There is weakly expressed the linear relationship between the soil reaction in H_2O and soil depth ($R^2=0.05$, $p=0.029$) and no relationship between the soil reaction in CaCl_2 and soil depth ($R^2=0.004$, $p=0.561$).

The values of the carbonate content are relatively low, which is expected based on the pH data. There is no significant linear relationship between CaCO_3 and depth ($R^2=0.027$, $p=0.256$). The studied soils are generally characterized by low SOM and TKN values, which is consistent with Donovan (1993) and Singh et al. (2000). The SOM and TKN are between 1.13 and 2.18%, 0.001 and 0.020% in the upper (0-20 cm) layer, between 0.87 and 1.91%, 0.002 and 0.012% at 20-40 cm, 0.88-1.88% and 0.001-0.012% at 40-60 cm depth, between 0.20 and 1.07%, 0.001 and 0.011%, at 60-80 cm and between 0.08 and 0.96%, 0.001 and 0.010% respectively in the lower (80-100 cm) layer. There is a strong linear negative relationship between SOM and the depth ($R^2=0.603$, $p<0.001$), and a weaker one, although statistically significant, between TKN and the depth ($R^2=0.13$, $p=0.004$) (figures 7 and 8)

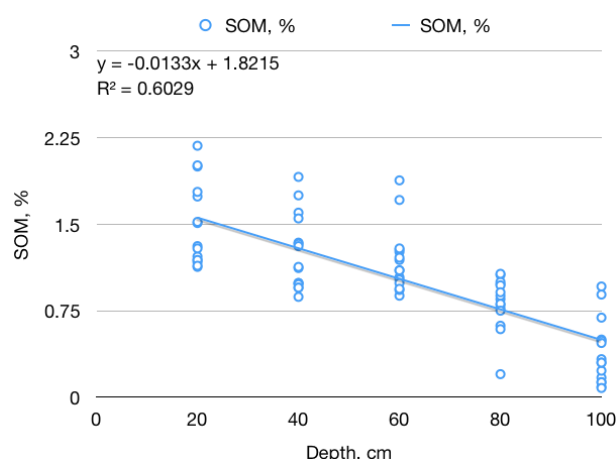


Fig. 7. The relationship between depth and SOM.

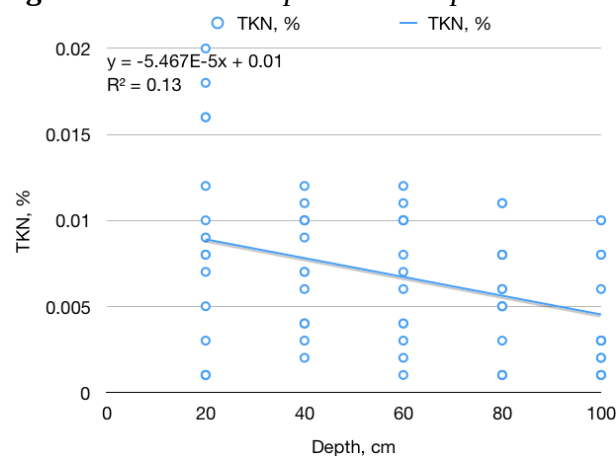


Fig. 8. The relationship between depth and TKN.

The studied soils are characterized by a very low availability of P_2O_5 and an average of the very good availability of K_2O . The P_2O_5 and K_2O are between 0.06 and 0.43 $mg.100g^{-1}$, 0.75 and 56.25 $mg.100g^{-1}$ in the upper (0-20 cm) layer, between 0.04 and 0.2 $mg.100g^{-1}$, 1.37 and 14.81 $mg.100g^{-1}$ at 20-40 cm, 0.09-0.17 $mg.100g^{-1}$ and 0.09-14.05 $mg.100g^{-1}$ at 40-60 cm depth, between 0.20 and 0.13 $mg.100g^{-1}$, 0.43 and 11.74 $mg.100g^{-1}$, at 60-80 cm and between 0.03 and 0.16 $mg.100g^{-1}$, 0.16 and 15.56 $mg.100g^{-1}$ respectively in the lower (80-1000 cm) layer. There are low linear negative relationships between P_2O_5 and depth ($R^2=0.264$, $p<0.001$), and between K_2O and depth ($R^2=0.161$, $p=0.006$). The relatively low level of relationship, as illustrated by the coefficient of determination (R^2), are due to the high variation of P_2O_5 in the first layer, which decreases downward to the 60-80 cm layer, and the high variation of K_2O in the first layer, followed by an almost similar variation in the next layers (figures 9 and 10).

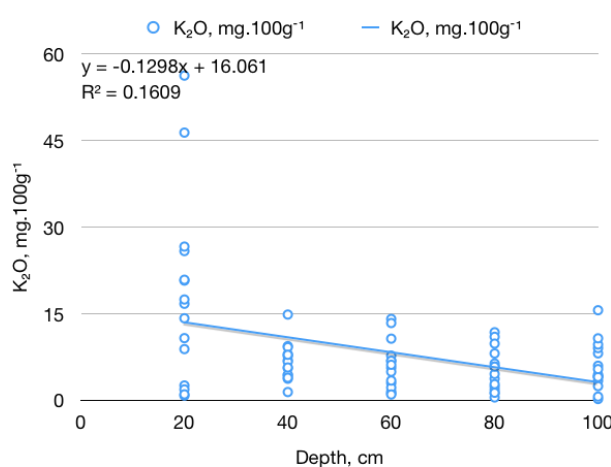


Fig. 9. The relationship between soil depth and P_2O_5 content.

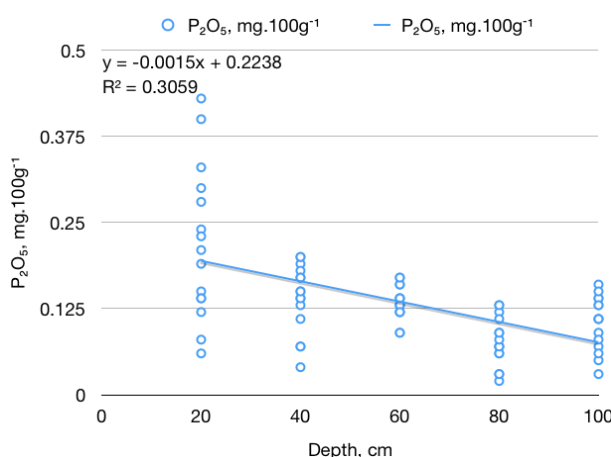


Fig. 10. Relationship between soil depth and K_2O content

Plant cover

As a result of the field studies carried out, 28 species of higher plants were identified in the studied territory. It should be emphasized immediately that this composition represents only part of the plant species on the site. By the time the study was carried out, spring species

(ephemerides and ephemeroids) had completed their vegetation period and could only be encountered incidentally. A cereal grass turf had formed on all observation sites and the projection coverage is about 80%. Couch-grass (*Cynodon dactylon* L.) predominates with a projective coverage of about 70%. *Poa pratensis* L. and *Arrhenatherum elatius* (L.) P. Beauv. Ex J. & C. Presl of the cereals account for several percents (up to 5), and in certain areas, up to 1-2% of the cover consists of large-sized species such as *Dipsacus fullonum* L.

Table 2. List of identified species

Species	Family	Geo element	Biological type
<i>Achillea millefolium</i> L.	Asteraceae	Eur-Sib	P
<i>Agrimonia eupatoria</i> L.	Asteraceae	Eur-Med	P
<i>Arrhenatherum elatius</i> (L.) P. Beauv. ex J. & C. Presl	Poaceae	Eur-As	P
<i>Artemisia absinthium</i> L.	Asteraceae	Pont-Med	P
<i>Artemisia vulgaris</i> L.	Asteraceae	subBoreal	P
<i>Berteroa incana</i> (L.) DC.	Brassicaceae	SPont	P
<i>Chenopodium album</i> L.	Chenopodiaceae	Kos	A
<i>Chondrilla juncea</i> L.	Asteraceae	Eur-Sib	P
<i>Cichorium intybus</i> L.	Asteraceae	Eur-Sib	P
<i>Cirsium arvense</i> (L.) Scop.	Asteraceae	Eur-As	A
<i>Convolvulus arvensis</i> L.	Convolvulaceae	Kos	A
<i>Conyza canadensis</i> (L.) Cronquist	Asteraceae	Adv	A
<i>Cynodon dactylon</i> (L.) Pers.	Poaceae	Kos	P
<i>Dactylis glomerata</i> L.	Poaceae	Eur-As	P
<i>Daucus carota</i> L.	Apiaceae	Eur-As	B
<i>Dipsacus fullonum</i> L.	Dipsacaceae	Eur-OT	B-P
<i>Echium vulgare</i> L.	Boraginaceae	Eur-As	B-P
<i>Elymus repens</i> (L.) Gould.	Poaceae	Boreal	P
<i>Euphorbia cyparissias</i> L.	Euphorbiaceae	Eur	P
<i>Galium verum</i> L.	Rubiaceae	Eur-As	P
<i>Linaria genistifolia</i> (L.) Mill.	Scrophulariaceae	Pont-Sib	P
<i>Persicaria maculata</i> (Raf.) Gray	Polygonaceae	Eur-As	A
<i>Poa pratensis</i> L.	Poaceae	Kos	P
<i>Prunus cerasifera</i> Ehrh.	Rosaceae	Eur-As	T
<i>Rumex patientia</i> L.	Polygonaceae	Eur-As	P
<i>Saponaria officinalis</i> L.	Caryophyllaceae	Eur-Sib	P
<i>Scabiosa argentea</i> L.	Dipsacaceae	Bal-Anat	B-P
<i>Taraxacum officinale</i> Webb	Asteraceae	Eur-Med	P

Legend: For the designation of the geo elements – see Assyov and Petrova, eds. (2012).

For biological type: A – annual plant, B – biennial plant, B-P – biennial to perennial plant, P – perennial plant, and T – tree.

The grass mixture consists of single specimen or small groups of other species, the most common of which are *Berteroa incana* (L.) DC., *Chondrilla juncea* L., *Achillea*

millefolium L. and *Galium verum* L. The other species are of a more limited occurrence and have been encountered on one or two observation sites. A list of the species has been provided below in Table 2.

The Asteraceae family is the most numerous, represented by 9 species, followed by the Poaceae family – 5 species. Dipsacaceae and Polygonaceae are represented by two species and 10 families are represented by one species.

According to the biological type, 5 species are annual herbaceous plants, 1 species is a biennial herbaceous plant, 3 species are biennial to perennial herbaceous plants, 18 species are perennial herbaceous plants, and one species is a tree, which is, however, represented by a small specimen hardly distinguishable in the grass community.

According to the geographical origin of the species, 13 types were identified. The most numerous are the Euro-Asian elements (Eur-As) – 9 species, followed by Euro-Siberian (Eur-Sib) and Cosmopolitan (Kos) geo elements – 4 species each. The Euro-Mediterranean elements (Eur-Med) are represented by two species, and the other geo elements are represented by one species each (Fig. 11).

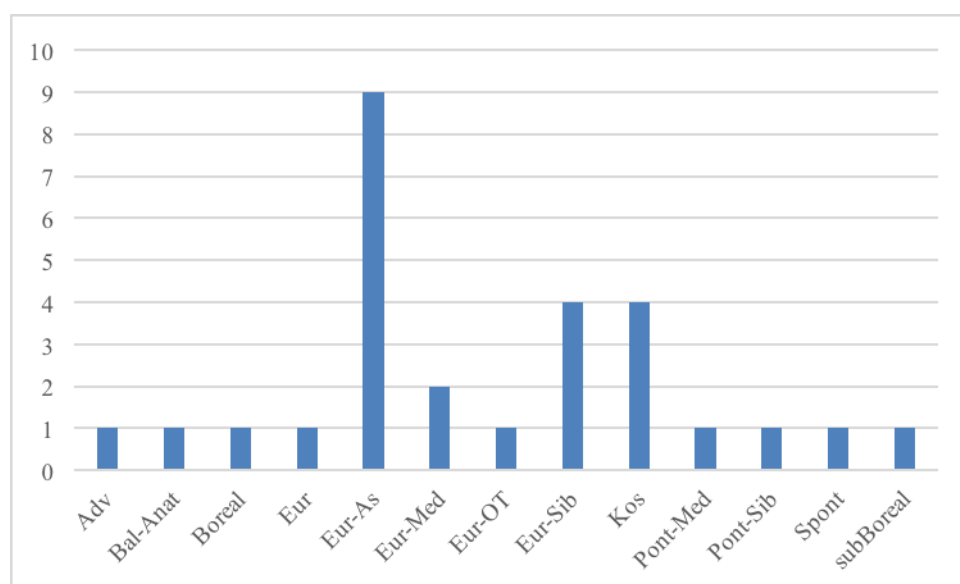


Fig. 11. Geoelements in the studied territory (according to Assyov and Petrova, eds., 2012).

Soil formation process

The soil forming factors influence the nature, direction and speed of soil forming processes (Donov, 1993). The key factors are climate, biota, topography, and parent material. *The climate* has a direct influence on the temperature and moisture of the soil, and an indirect one on the biota. In terms of climate, the subject of study falls within the European continental climatic region, temperate continental sub-region, the climatic region of the high fields of Mid-Western Bulgaria (Troeva, 2009). The retention and additional radiative cooling of air masses are typical of the territories around Sofia, and this results in temperatures as low as -25 °C. The average temperatures in January are about 4–5 °C, and the average temperatures in June are 20–21 °C. The relative air humidity is 70%. The average annual temperature of the studied area varies around 11.5°C, the average annual rainfall varies around 837 mm, with a peak rainfall in May and a minimum in July. The winter is cold

and relatively dry with an average temperature in January of 2.6 °C. There is a small amount of rain (102 mm). The summer is relatively warm with an average temperature in July~23.8°C. There is significantly more rainfall in the fall than in the spring. This is due to the basic features of this region (Troeva, 2009). Small amounts of precipitation fall in July, August and September (Fig. 2). Climate is continental, with highest mean monthly temperature in July and the lowest – in January, and with highest precipitation amount in May and lowest – in September (Fig. 12).

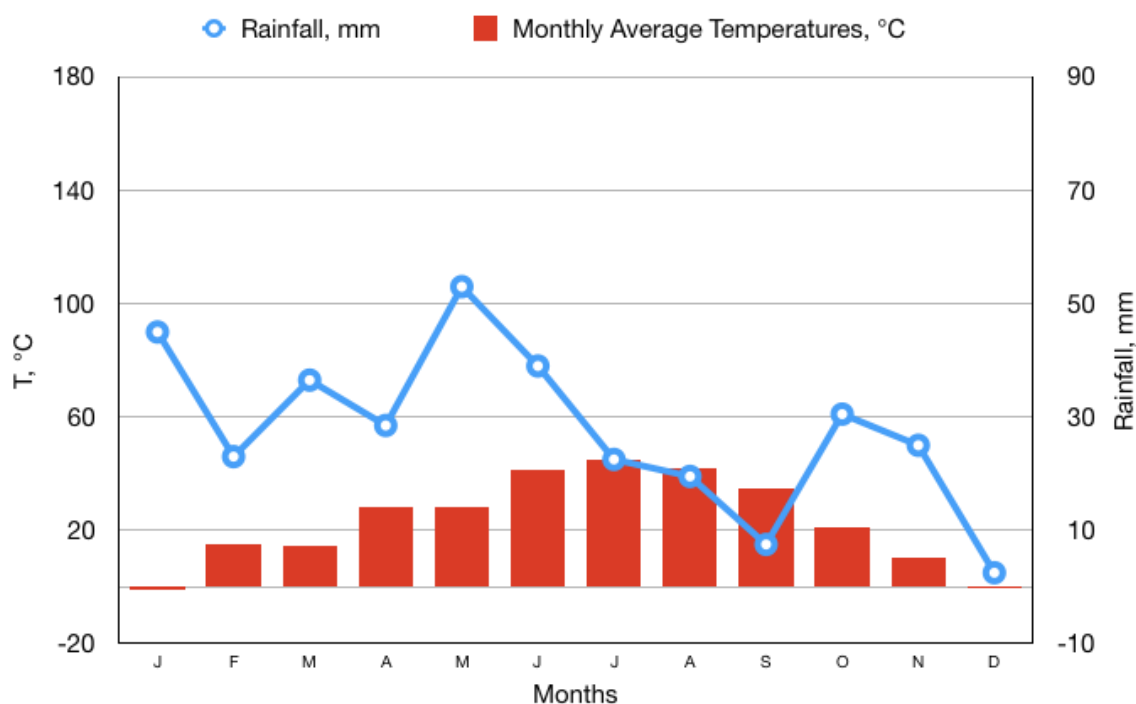


Fig. 12. Climate diagram 2016 of the region of study (NIMH, BAS, 2016).

Higher plants are the most significant *biotic* factors that shape the formation of soils, microclimate, supply the soil with organic matter and influence its composition and properties (Donov, 1979). A number of plant species are closely related to the soil properties by influencing plant development, or by indicating changes in the soil substrate (Bogdanov & Glogov, 2006; Bogdanov, 2013, 2014; Bogdanov et al., 2015). The soils have been formed under poorly developed meadow vegetation (Stransky, 1935; Georgiev, 1959; Donovan, 1979). Forests develop less frequently on such soils (Stransky, 1935), but if they do, in Bulgaria they form riparian ecosystems dominated by poplars (*Populus* spp.) and willows *Salix* spp., and less frequently – by Common oak (*Quercus robur* L.) and Ashes (*Fraxinus* spp.) (Bondev, 1991). In more northern conditions they may be composed of *Picea* spp., *Larix* spp., *Betula* spp., *Ulmus* spp. (Zelikov, 1981). Meadow-marsh vegetation and more rarely, salt-tolerant vegetation develop in lower regions (Stransky, 1935). The study on Fluvisols in the Sofia hollow showed that the most numerous families are Asteraceae, Poaceae and Rosaceae. Many families are represented by a single species. Euro-Asiatic floristic elements form the most numerous group of species phytogeographic origin, followed by cosmopolitan elements. European and Euro-Mediterranean elements come next by low representation. The adventive

species are fewer than 10%. Four groups are represented by a single species, which makes a percentage ratio of 1.25% (Ilinkin et al., 2014).

The parent material is a river deposit, mostly sandy, which becomes finer and finer as the river flows from its source to its mouth. It is layered due to its periodic precipitation when rivers burst their banks (Georgiev, 1959; Donovan, 1993). These soils are young, at an early stage of development. Their periodic flushing by fast-flowing rivers during flooding and the precipitation of new sediments prevent the occurrence of permanent vegetation and soil formation (Georgiev, 1959; Donovan, 1993). Over the short period of their existence, no genetic horizons have formed. There are only separate layers, or a poorly developed primordial humus horizon (Donovan, 1993) 1-10 (30) cm thick (Zelikov, 1981), followed by different sediment layers. The soils located downstream are characterized by basic soil processes of humus formation and humus accumulation (Zelikov, 1981; Donovan, 1993). Depending on the strength of the water current, a big or a small amount of large or tiny particle material is deposited all at once, which forms thicker or thinner soil layers. Alluvial embankments form soil layers that do not have a genetic link. The soil profile is of type I, II, III, IV, V, etc., AC₁C₂C₃C₄C₅, or AI II III IV V, etc. with a well-developed humus-cumulative horizon (Donovan 1979; Donovan, 1993).

Conclusion

The complex influence of soil formation factors (as periodical depositing of parent material) determines a variation of different soil characteristics (such as bulk density, pH, etc) and because of this, there are weak relationships between different soil characteristics and soil depth. There are moderate to high relationships between some soil characteristics such as clay, sand, porosity and soil organic matter and soil depth and weak and insignificant relationships between the other characteristics and soil depth. There are significant correlations among the physical and chemical soil properties in one-third of all possible cases and this is a result of the fact that many characteristics depend on the same factors and are the result of similar processes.

The studied soils are characterized by some favourable physical properties, e.g. porosity (in upper layers) and PAWC. The soil texture variation from loamy sand to sandy clay loam determined the soils as light by texture and favourable for a wide set of species (and varieties) for a restoration of the environment. Some examples – Indigenous arboreal species: *Pinus nigra* Arnold, *Alnus glutinosa* (L.) Gaertn., *Carpinus betulus* L., *Populus alba* L., *Salix alba* L., *Salix fragilis* L., *Cornus sanguinea* L., *Frangula alnus* Mill.; Exotic arboreal species: *Picea pungens* Engelm., *Taxodium distichum* (L.) Rich., *Cupressus arizonica* Greene, *Salix babylonica* L., *Salix viminalis* L., *Liquidambar styraciflua* L., *Berberis thunbergii* DC. Herbaceous species: *Elymus repens* (L.) Gould., *Poa trivialis* L., *Arrhenatherum elatius* (L.) P. Beauv. ex J. & C. Presl., *Lolium perenne* L., and some appropriate grass mixtures for the establishment of a meadow-like environment.

The SOM, TKN and P₂O₅ are in low (but normal for this soil type) contents. The variation of soil pH between 6.0-7.0 reduces the availability of some elements (Gorbanov et al., 2005), which can reduce the plant nutrition of P₂O₅. The K₂O content is high.

Activities for the restoration and productivity increase of the suburban ecosystems in the region should be planned in accordance with soil characteristics and particularly with its specific chemical composition.

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Some examples for references to journal publications, books, chapters in edited books and electronic publications or databases:

- Atanassova, I., S. Doerr, 2010. Organic compounds of different extractability in total solvent extracts from soils of contrasting water repellency. *European Journal of Soil Science*, 61, 298-313.
- Schwesig, D., A. Göttlein, L. Haumaier, R. Blasek, G. Ilgen, 2013. *International Journal of Environmental and Analytical Chemistry*. URL: <http://dx.doi.org/10.1080/03067319908032668>.
- Calderón, H. W., 1982. The content and composition of humus in arid alluvial soil of Peru. *Soil Science, Academy of Sciences of USSR, Moscow*, 8, 53-59. (in Russian)
- Sparks, D. L., 2002. *Environmental Soil Chemistry*, 2nd Edition, Academic Press, San Diego, CA
- Sparks, D. L., P.M. Huang, 1985. The physical chemistry of soil potassium. In: R.E. Munson (ed.) *Potassium in agriculture*. Soil Science Society of America, Madison, WI. p. 201-276.
- Noyes, J. S. 2013. Universal Chalcidoidea Database. World Wide Web electronic publication. Last update 29 August 2013. URL: <http://www.nhm.ac.uk/chalcidoids>.

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